PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

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Monday, 15th February 1869.

Dr CHRISTISON, President, in the Chair.

At the request of the Council, Mr Geikie gave the following Address on the Progress of the Geological Survey of Scotland.*

Before proceeding to the special subject of this address, I have thought that it might be of interest to the Society to lay before them a brief outline of the history of geological map-making in Scotland, previous to the time when the task was undertaken by the Geological Survey. I do not, indeed, presume to enter upon any general retrospect of the literature of Scottish geology, but will content myself with selecting for remark a few of the more eminent contributors, on whose labours the present general geological maps of the country are based. These maps are compiled from the results obtained by many different geologists, working independently during the last fifty or sixty years. Some of the men whose researches have in this way been made use of, never themselves produced any map, but their descriptions of the districts traversed by them served afterwards as a basis for the maps of others.

The first geologist who attempted to map any large district of

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* As a rule, the results of the Geological Survey are not published until they appear in the proper official form. When, however, the Council of the Royal Society requested me to give an account of the progress of the Survey, I felt that the ordinary rule might here with much advantage be set aside; and on referring the matter to the Director-General, Sir Roderick Murchison, he took the same view, and cordially gave his assent.

Scotland in considerable detail, was Dr MacCulloch. During a series of years he employed himself in carrying on a geological survey of the Western Islands, and published the results from time to time in the Transactions of the Geological Society of London. At length, in the summer of 1819, he collected these scattered notices, rearranged and enlarged them, and published them as his well-known work on the Western Islands. Accompanying the text was a volume of plates, including detailed maps of the islands, with sections explanatory of their geological structure. This is one of the most important contributions ever made to Scottish Geology. It laid down with some detail, and for the first time, the geological structure of the long chain of islands from the Isle of Man to the Butt of Lewis, along with a portion of the adjoining mainland. It was accomplished, too, at a time ere steamers had been established, and when travelling in that region entailed no little inconvenience, and even personal risk.

In the early part of this century there existed at Edinburgh a flourishing School of mineralogy and geology, under the leadership of Professor Jameson. That able and enthusiastic teacher infused into his pupils much of the zeal with which he himself pursued his favourite path of science. Though he travelled far and near over Scotland, and gave frequent notices of his labours to the various learned societies with which he was connected, he published but a small part of the mass of information which he had accumulated. It was indeed to his class at the University that he made known his observations and deductions, and he lived to see the seed which he had there sown bear goodly fruit in the career of not a few eminent naturalists. One of his early pupils, to whom the cause of geology in this country stands largely indebted, was Dr Ami Boué, a native of Hamburg, who had come to Edinburgh to study medicine, and who took his degree in the year 1817. During his residence in Scotland Boué greatly distinguished himself by his zeal in the prosecution of geology. He made long and frequent journeys in almost every part of the country, comparing the rocks of one district with those of another, and gathering together from his own observations, as well as from the recorded researches of others, a large and valuable mass of information regarding the geology of Scotland, which he published in Paris in the year 1822 as an "Essai Géologique sur l'Ecosse." This volume, besides its detailed descriptions of the rocks of the country, contains a coloured geological map, and a series of plates of illustrative sections. The map has a peculiar interest in our present inquiry. The outlines of the geological structure of the kingdom are there broadly sketched. He traces the general area occupied by the gneiss, and what he calls the "chloritic and quartzose rocks" of the Highlands, the position and extent of the great coal-field of the Midland Valley, and the limits of the "greywacke" of the Southern Uplands. He distinguishes the granites, syenites, and porphyries, and roughly separates the rocks of volcanic or trappean origin, according to their respective ages. In this latter subject his observations were far in advance of his time. He had studied some of the extinct volcanic districts of the Continent, and gained a familiarity with volcanic phenomena which gave him a great advantage over his Scottish contemporaries, who were still disputing whether or not the trap-rocks of their country had really a volcanic origin. The map on which Dr Boué inserted his broad generalisations was of course merely an outline or sketch, necessarily full of inaccuracies and omissions. But in some important respects it foreshadowed the maps that have succeeded it.*

While the Edinburgh School of Geologists continued to furnish descriptions, and sometimes also maps of different geological districts, Dr MacCulloch carried on his own independent researches, and brought them at intervals before the Geological Society of London. He had been required by the Board of Ordnance to make some special investigations, partly with a view to discover some one mountain, the geological structure of which might afford a prospect of repeating with greater reliability the experiments made by Dr Maskelyne upon Schihallien to estimate the weight of the earth. In the course of these and other journeys he had noted upon a map the geological structure of each district examined; and finding at last that a considerable area of the country had been thus delineated, he represented to the Board of Ordnance the propriety of securing a grant from Parliament to ensure a complete geological map of the whole country. This application was eventually acceded to by the Treasury, and Dr MacCulloch was empowered to extend and complete his survey at the public cost. The map on which he laid down his geological lines was that of Arrowsmith, on the scale of a quarter of an inch to a mile. It was published in 1832, and the memoir descriptive of it appeared in 1836, the author having meanwhile died from a melancholy accident in 1835.

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* Dr Boué still retains his youthful enthusiasm. He is resident at Vienna, from which place I have recently had some interesting letters from him, full of gossip about Edinburgh in the early part of this century, and of references to his own wanderings in Scotland.

MacCulloch's Geological Map of Scotland has long taken its place among the classics of geology. The outlines of the geological structure of the country are much more fully traced than Boué attempted on his little sketch-map; and although, like the latter, it is, and could not fail to be, full of errors and omissions, it must ever remain a remarkable monument of the industry of a single observer. It would have been well for MacCulloch's reputation had he lived to see through the press, the memoir explanatory of the map. We can hardly believe that, though he had written, he would in his calmer moments have published, so much intemperate invective against possible critics of his map, or so much special pleading which showed only too well how thoroughly he was himself aware of the shortcomings of his work. He would doubtless have come to see that the only course open to him was to show simply what he had done, what he wished to do had his materials and opportunities permitted, and to confess that his map, with all its imperfections, could only be regarded as a first rough draft of what he conceived a geological map of Scotland should be.*

The Transactions of the Geological Society of London, besides the numerous contributions of Dr MacCulloch, were likewise enriched with some valuable papers in Scottish geology by Sir Roderick (then Mr) Murchison and Professor Sedgwick. Such were their memoirs on the Red Sandstones of the northern counties, on the Structure of Arran, and Sir Roderick's first important essay—that on the Secondary Rocks of the north of Scotland.

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* In speaking of future corrections and improvements of his map, Dr MacCulloch remarks, that they will not require the energies of "a refined geologist." "The rocks are few, and it is easy to learn to recognise them; there is nothing which any man may not attain, on this narrow subject, with a few weeks of experience. It will confer no particular fame on any future self-constituted geologist, to have done what could have been effected by a surveyor's drudge, or a Scottish quarryman." [!]—*Memoirs to his Majesty's Treasury respecting a Geological Survey of Scotland*, 1836, p. 17.

Shortly after the publication of MacCulloch's map, the Highland and Agricultural Society of Scotland, impressed with the necessity of more detailed and accurate geological information than had yet been given, began to offer liberal premiums for surveys and descriptions of various parts of the kingdom. The result of this scheme was the publication of a series of prize essays and maps of different counties and districts, full of valuable information, and much more in detail than anything which had been before attempted for the same parts of the country. The first essay in the order of issue was that of Mr Milne-Home on Berwickshire, which appeared in 1836, and afterwards there came at intervals memoirs on the counties of Roxburgh, Peebles, Sutherland, Banff, Renfrew, Dumfries, Kirkcudbright, &c.

The Wernerian Society, also, about the same time, proposed a series of geological essays, with premiums for the successful competitors. One of the subjects for competition was a geological account and map of the three Lothians, and the prize was awarded in 1836 to Mr Hay Cunningham for his now well-known memoir on that subject published in the Society's Transactions.

The published journals of the different scientific societies continued to receive occasional contributions in descriptive geology with accompanying maps, such as Mr Milne-Home's account of Roxburghshire, Mr Stevenson's Geology of Cockburn Law and of the Eastern Lammermuirs, Sir R. Murchison's Geology of Carrick, and others; while now and then there appeared a separate work, such as Mr Maclaren's Geology of Fife and the Lothians.

Using MacCulloch's map as a basis, amending it, and adding to it the work of the different subsequent labourers in the field, Professor Nicol published a Geological Map of Scotland in 1858. Its scale was ten miles to an inch. Among the improvements which distinguished it from all preceding maps of the country was the separation of the red sandstone of the north-west coast from the old red sandstone of the rest of the island—a change rendered necessary by the results of the conjoint researches of Sir Roderick Murchison and Mr Nicol. In the year 1859, Sir Roderick, who since 1826 had from time to time published important contributions on the geology of his native country, gave to the world a geological sketch-map of the Scottish Highlands, based upon the results of the labours of several summers spent by him in the north-western counties. In this map the crystalline rocks of the Highlands were for the first time brought into recognisable geological relationship to the other rocks in the British islands. Taken along with the different memoirs of which it was an embodiment, it may indeed be said to have revolutionised the geology of the northern half of the kingdom. Subsequently, after an exploration of the Western and Central Highlands by Sir Roderick and myself in company, we published in 1861 a first sketch of a new geological map of Scotland, in which the geological structure of the Highlands (as distinguished from the mere distribution of different kinds of rock) was more definitely traced; the subdivisions of the old red sandstone and carboniferous formations were put down, and an attempt was made to arrange chronologically the different trappean rocks of the kingdom. The map was on a very small scale, and was necessarily imperfect, and in places erroneous, being offered only as a rough outline to show in a graphic form our views of the general geological structure of the country.

The necessity of a detailed investigation of the structure of the United Kingdom was recognised by Parliament in 1835, and Sir Henry de la Beche, who had at his own charges made some progress in a survey of the south-west of England, was empowered to employ some assistants, under the Board of Ordnance. His small staff was called the Ordnance Geological Survey. Subsequently, in 1845, the great advantages of such a survey having by that time been more fully perceived by Government, the number of geologists was increased, and the staff transferred from the Board of Ordnance to the Board of Works. Since that period the geological survey has grown still further, and is now under the Department of Science and Art.

The object of this national Survey is to ascertain in detail the geological structure of the country, to publish illustrative maps, sections, and descriptive memoirs, and to collect and exhibit specimens of the rocks, minerals, and fossils met with in the course of the inquiry. The maps on which the field work is conducted are those prepared by the Ordnance Survey. Hence as these maps must be obtained before geological surveying can go on, the progress of the Geological is necessarily in a great measure dependent upon that of the Ordnance Survey. Owing to the want of the Ordnance maps, it was not possible to extend the Geological Survey to Scotland until the year 1854, when a beginning was made by Professor Ramsay. Only two geologists could be spared for the Scottish survey, and this continued for several years to be the whole of the staff employed in this part of the United Kingdom, the backward state of the Ordnance Survey rendering any considerable increase of the geological surveyors impossible. At last, a more liberal Parliamentary grant enabled the Director of the Ordnance Survey to proceed much more rapidly with the publication of the Ordnance maps. It therefore became desirable to expedite at the same time the progress of the Geological Survey, and the late Government, after a full consideration of the subject, towards the close of the year 1866 resolved to reconstruct the staff of the Geological Survey, and largely to increase its numbers. Hitherto the establishment had consisted of two branches—one for Great Britain, with head-quarters in London, and one for Ireland, with head-quarters in Dublin. It was now determined that there should be three branches, each under a separate resident director, and with an adequate staff—one for England and Wales, under Professor A. C. Ramsay; one for Ireland, under Mr Jukes; and one for Scotland, under my own charge; the three branches still remaining under the control of the Director-General, Sir R. I. Murchison. With this great increase of strength, the Geological Survey of Scotland is now making rapid progress; and as the Ordnance maps of the whole of the southern half of Scotland are published, no hindrance is anticipated in the completion of the geological investigation of that part of the country.

On a former occasion,* I had an opportunity of laying before the Society a narrative of the progress of the Survey during the first ten years of its existence. I pointed out that, commencing in East Lothian, it gradually crept westward to the borders of Stirlingshire, and southwards to those of Dumfries, Roxburgh, and

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* Address given at the request of the Council on 6th February 1865. See Proceedings, vol. v. p. 355.

Berwick; that its further advance into the central coal-field being impossible for want of the Ordnance maps, it was transferred to Fife, and spread over the whole of that county and Kinross to the Firth of Tay and the confines of Perthshire; and that the maps of the Clydesdale and Stirlingshire coal-field still failing, the geological surveying was at last commenced from a new centre in the south of Ayrshire during the autumn of the year 1863. Since that time the work has advanced steadily northwards and eastwards. The large county of Ayr is now surveyed, and the maps of it partly published, and partly engraving. Half of Renfrewshire is finished, and the survey of the Clyde coal-field under my colleague Mr Hull, is advancing round Glasgow. The work of the Survey is now extended across the island from sea to sea, and is at present diverging from this completed belt, northwards through the rich mineral-fields of Lanarkshire and Stirlingshire, and southwards over the counties of Wigtown, Kirkcudbright, Dumfries, and Peebles.

The field-work is traced upon the six-inch maps of the Ordnance Survey, and is then reduced and engraved upon the one-inch maps; the general geological map of the whole kingdom being published on the scale of one inch to a mile. But wherever any workable minerals occur, in addition to this general map, there are likewise issued sheets on the six-inch scale, on which all necessary geological details are inserted. In this manner all coal-fields are published on the large scale, though also included in the general geological map on the smaller scale. In order, however, that the large amount of detail necessarily accumulated as the Survey advances may be made as useful to the public as possible, manuscript copies of six-inch maps, which are not to be published, are furnished under certain conditions. Landed proprietors, engineers, and others thus obtain detailed geological surveys merely at the cost of the manual transcription of the original field-maps.

The area which has now been mapped amounts in all to about 4100 square miles. Of this area, 2269 square miles have been published on the one-inch scale. About 800 square miles are now in the course of being engraved, and the rest is in progress. Nine sheets of the one-inch map have been published, comprising the whole or parts of the counties of Edinburgh, Haddington, Linlithgow, Fife, Kinross, Peebles, Selkirk, Lanark, Ayr, and Kirkcudbright. In addition to these maps on the scale of one inch to a mile, thirty-six sheets of the coal-field maps, on the scale of six inches to a mile, have been published, including the coal-fields of Mid-Lothian, East Lothian, Fife, and Ayrshire. A considerable number more, now in the hands of the engraver, embrace the northern half of the Ayrshire coal-field, with part of the great coal-basin of the Clyde. In addition to the maps, sheets of horizontal sections are published, to explain the structure of the country, and also vertical sections, to illustrate the strata of the different coal-fields. Descriptive memoirs are likewise issued along with the maps, giving the detailed evidence on which the geological lines have been drawn, list of fossils, and all important information obtained in the course of the survey.*

I shall now proceed to indicate some of the more important scientific results which have been obtained by the Geological Survey of Scotland during the four years which have elapsed since I last addressed the Society upon this subject. Beginning with the oldest rocks we have examined, I may remark that the complicated Silurian geology of Carrick has been mapped, and a large suite of fossils collected from that district. From the south-west of Ayrshire the lower Silurian rocks have been traced across Nithsdale and Clydesdale into the valley of the Tweed. In the prosecution of the work, within the last few months an important discovery has been made by one of the younger members of the Survey, Mr R. L. Jack—viz., the occurrence of a bed of fossiliferous conglomerate, which has been traced for about five miles among the Leadhills. The fossils have not yet been examined, but there seems much probability that this bed will prove to be a prolongation of the well-known Wrae limestone, and thus define the age of the strata of the Leadhill district. A large area of Old Red Sandstone has now been examined, including the whole region between St Abb's Head and the south-west of Ayrshire. Three distinct divisions have been ascertained—an upper series, graduating upwards into the Carboniferous formation, well seen in East Lothian; a middle group, extensively developed, to the south of the town of Ayr; and a lower group, which reaches an enormous thickness, and passes down into the Upper Silurian. In this lower division, as it approaches its north-eastern limit, a remarkable local unconformity has been ascertained by the recent researches of Mr B. N. Peach and myself. In the Pentland Hills the conglomerates and sandstones rest upon the vertical abraded edges of the Upper Silurian rocks; while only a few miles distant, in the parish of Lesmahagow, there is no such break, but the one series passes regularly into the other. The Pentland Hills, therefore, contain two groups of strata, both belonging to the lower Old Red Sandstone, but the one lying quite unconformably on the other. It seems not improbable that the great development of contemporaneous igneous rocks associated with these strata in the Pentland area may have had something to do with the origin of this local break in the succession of the deposits.* Much attention has been bestowed by the Survey during the last few years upon the lower members of the Carboniferous system. The result is that a twofold division has been made of that hitherto vaguely defined set of strata called by the late Mr Charles Maclaren the Calciferous Sandstones, and lying between the top of the Old Red Sandstone and the base of the Carboniferous limestone. New light has consequently been thrown upon the history of the earlier portions of the Carboniferous period in Scotland. The lower part of the Calciferous sandstones consists of a thick but variable group of red sandstones extensively developed in Ayrshire, Arran, and Bute, and stretching, as I have now ascertained, across the island to the coast of Haddington and Berwick. Between these lower sandstones and the base of the Carboniferous limestone comes a group of strata possessing much interest from the variations which it exhibits in thickness and in the nature of its component strata. In some districts it is altogether absent, and then the limestones and the red sandstones come together. But again, at no great distance, it reappears, and soon acquires a considerable thickness. In the western part of the country, it consists of grey and white sandstones, pale grey, green, or mottled marls and shales, with bands of cement stone, sometimes with dark shale and ironstone. The Ballagan beds of the Campsie Hills belong to this group. In the eastern half of the country, throughout the Lothians, it is made up of thick white sandstones, black shales, ironstones, some beds of limestone, and even of coal, its most important components being those bituminous shales from which oil is now so extensively obtained. In the east of Fife it contains a great many bands of limestone, having the fossils and general aspect of true carboniferous limestone beds, while in Berwickshire it reassumes the aspect which it shows in Ayrshire and the west.

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* In the course of his remarks, the speaker pointed to a large map of the southern half of Scotland, on the scale of one inch to a mile, on which all the area yet surveyed by the Geological Survey was coloured. There were likewise suspended on the wall specimens of the maps of the coal-fields of Fife and Ayrshire, on the scale of six inches to a mile; specimens of the horizontal and vertical sections, and of the duplicate manuscript maps preserved in the office of the Survey.

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* In Vol. V. of the Proceedings of this Society, p. 360, I have given a section of the Pentland Hills, which remains true, though I have since learnt more of the relations of the rocks there shown to the structure of this country at large. The series in the section marked *c* is stated to be "a middle division of the Old Red Sandstone," which is locally true, though more extended researches show that the great discordance between *c* and *b*, disappears in the course of a few miles. *c* is in reality only an upper unconformable portion of *b*. Again, the relation of the strata marked *e* to those below is correctly shown in the section, but I am now convinced that the red sandstones of the Cairn Hills (*e*) are only a prolongation of that great band of red sandstones which forms the base of the Carboniferous series throughout the west of Scotland.

During the progress of the Survey in Ayrshire, we have been fortunate enough to bring to light a new page in the history of volcanic action in this country—viz., the existence of a remarkable series of melaphyres, porphyrites, ashes and volcanic agglomerates, interbedded in the Permian series of that county and of Dumfriesshire. These rocks are of Permian age, and prove the existence of a group of active volcanic vents at that geological period in the south-west of Scotland.* In connection with this subject, I may mention that we have now accumulated a large body of evidence regarding the dates and extent of ancient volcanic action in Scotland. The oldest volcanic rocks we have yet encountered belong to the Lower Old Red Sandstone; they are well seen in the chain of the Ochil Hills, and in the range of broken heights which stretches from the Braid Hills at Edinburgh south-westward across Clydesdale and Nithsdale, almost to the coast of Ayrshire. Then comes a group which seems to form a middle division in the Old Red Sandstone, and is seen in the south of the county of Ayr. The

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* See Geol. Mag. for June 1866.

Upper Old Red Sandstone shows traces of contemporaneous volcanic activity in Berwickshire. During the early half of the Carboniferous period the volcanic forces were amazingly busy all over central Scotland. To that time must be referred the hills of the south of Arran and of Bute, the north of Ayrshire, Renfrewshire, the Campsie Fells, and most of the craggy hills which roughen the basin of the Forth from Stirling to the May Island and the Bass Rock. Then come the Permian volcanic rocks of the south-western counties. And lastly, we have those strange persistent dolerite dykes, which cross all the other rocks and even large faults, and which range from south-east to north-west, or from east to west towards the great mass of dolerites and basalts stretching from the south of Antrim along the western seaboard of Scotland. Those dykes I have formerly shown to the Society to be probably of miocene age.*

Several areas of metamorphic rocks have been mapped. The gradual passage of ordinary sedimentary rocks into crystalline compounds, and thence into various porphyries, syenites, and granites has been traced, particularly by Mr James Geikie, both among the Lower Siluran and Lower Old Red Sandstone series of Ayrshire. The details which have been gathered in the course of these investigations will, it is hoped, throw considerable light upon the metamorphism of rock-masses.

While the structure of the rocks underneath is thus delineated on the maps, attention at the same time is directed to the superficial deposits, which are all mapped out in the same detail. The various divisions of the Drift series are traced, and as the work advances the movements of the ice of the glacial period become from month to month more clear. We are now at work among the uplands of Galloway, and I anticipate thence a large accession of information regarding the history of the Ice Age in Scotland.

It is impossible that, while these various investigations are in progress, attention should not often be called to the relation between the structure of the rocks underneath and the form that they assume above ground. The nature of our work necessitates frequent reflection upon this subject, and implies the accumulation of a large mass of data from which the origin of the present outlines of the country may be deduced. These data are published upon the maps and sections. They seem to me to prove irresistibly the truth of the doctrine, which was first propounded within the walls of this Society by Hutton, that the existing contour of the land is not to be traced back to the operation of earthquakes, upheavals, and depressions, but mainly to the eroding influences of rain, springs, rivers, ice, and the sea. In illustration, I would point to the map suspended upon the wall, and show how the lines of large fracture ascertained by the Geological Survey are not marked at the surface, as a general rule, by any corresponding valley or depression; while, on the other hand, the existing valleys and ravines, instead of coinciding with lines of fault, as is too often assumed, in reality run across these lines in all directions, and without any reference to them at all. It must be a subject of congratulation among the Fellows of this Society to find that the views propounded here by their illustrious predecessor Dr Hutton, after being almost lost sight of for more than half a century, are now everywhere gaining ground rapidly, and that there is a growing recognition of the genius of that great man. Hutton, as it appears to me, is the true father of modern physical geology. Only now are we coming abreast of him, so far was he in advance of his time.

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* See Proceed. vol. vi.; and Address as President of the Geological Section of British Association, 1867.

The following Communication was read:—

On Traces in the Adult Heart of its transitions in form during Fœtal Life. (Part I.) By P. D. Handyside, M.D. (With a Plate.)

In this paper the author described in the adult human heart *certain vestiges of structures* which, during fœtal life, exist in an entire and perfect state. At birth, however, these, ceasing to be of use, generally disappear.

In allusion, *first*, to the Eustachian valve, he exhibited (and illustrated by the annexed sketch, fig. 1), an apparently unique specimen—obtained in his dissecting-rooms about six years ago—namely, a very large and reticulated Eustachian valve, prolonged at its middle third in the form of a semi-insulated cribriform fibrous lamina, taking a crescentic form continuously throughout, and after a valvular manner ending at the distance of three-sixteenths of an inch from the crest or rim of entrance of the superior vena cava.

After alluding, *secondly*, to the significant case shown and described to the Society on the 4th ult. by Professor Turner, Dr Handyside showed (fig. 2), and gave a sketch of—

Thirdly, another specimen from his rooms, which presents on the posterior wall, and at the rim of entrance, of the superior cava a well defined and deep lacuna, within which open five large Thebesian foramina. The caval half of the patulous border of this lacuna is protected by an oblique semilunar valve, one quarter of an-inch in breadth and of a like depth. This valve is composed of a duplicature of endocardium, and is evidently designed to secure the entrance of blood into the auricle.*

The author next compared shortly these three abnormal cases, demonstrating how they formed at once a graduated scale or anatomical series mutually illustrative, each specimen introducing to the mind its own peculiar features of morphological interest. He considered, however, these cases as chiefly interesting—when compared with the results of certain changes undergone by the human embryo between the third and the seventeenth weeks after conception—in relation with the structural affinities they present to permanently impressed forms in some cold and warm-blooded

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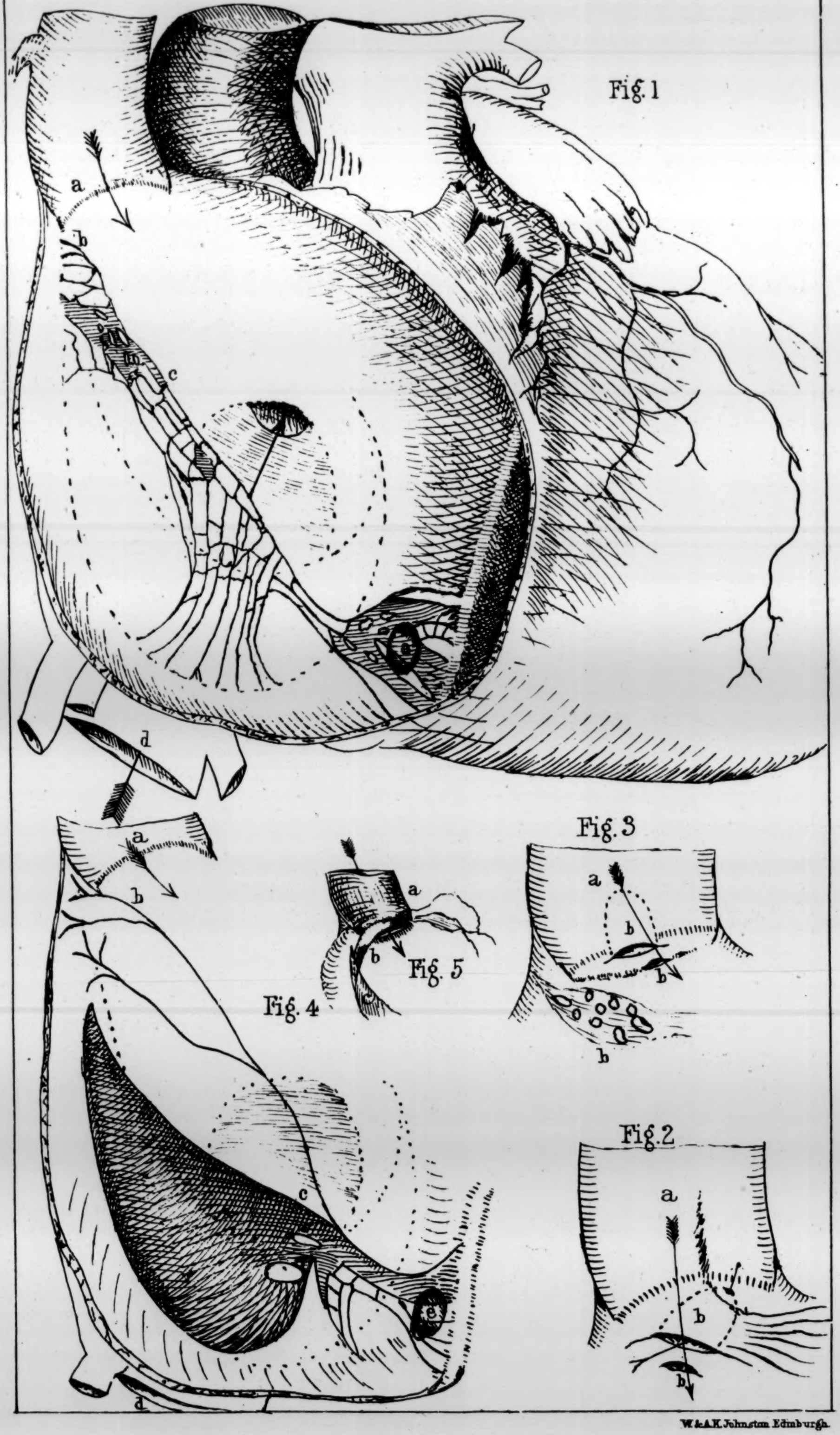
* The additional sketches, figs. 3 and 4, represent peculiarities in two adult hearts, and fig. 5, in a fœtal heart, dissected in Dr Handyside's rooms. In fig. 3 a valve (¼ inch broad by ¼ inch deep), formed of endocardium with an intervening lamina of striped muscle, lay within and parallel to the posterior segment of the rim of the superior cava. In fig. 4 is an unusually large persistent Eustachian valve, continuous at its left insertion with a still more remarkable Thebesian valve. The former, which is very large, has an insulated fibrous offset from its left extremity, which runs half-way across the sinus venosus towards the tubercle of Lower, and then dichotomously divides and subdivides thrice before it is implanted into the arched line between the right cornu of the Eustachian valve and the right segment of the rim of the superior cava. Fig. 5 represents, in a male fœtus of 6½ months, presented to Dr Handyside's museum during last summer, the occurrence of a complete semilunar valve situated at the termination of the upper vena cava, its convex border being attached to the anterior and right wall of the vein, its concave free border projecting into the auricle. The right crus of this valve is inserted into the auricular wall on a plane ¼ of an inch behind, and decussating, the right ascending cornu of the prolonged Eustachian valve.

a. Superior Cava, – b. Valves, and traces of Valves, there, – c. Eustachian Valve, – d. Inferior Cava, – e. Thebesian Valve.



W. & A. K. Johnston Edinburgh.

TRACES OF TRANSITIONS IN THE FŒTAL HEART.

(natural size)

BRITISH
7 MA 70
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animals; after a like manner to what is seen in the venous system of fishes as a *permanent* form of structure, and yet presents itself, but *temporarily* in the history of the development, during their embryo state, of *higher* vertebrate animals. He referred to homologues in the Myxinoidei family of *fishes;* to the Ophidian order of *reptiles;* among *birds*, to the *Aquila chrysäetos* and the *Casuarius emeu;* and among *mammals*, to the *Delphinus phocœna*, the *Macropus*, the *Elephas*, the *Stenops potto*, the *Simia gorilla*, and the *Simia troglodites*.

The author's view then, morphologically, is—1, That structures evolved *progressively*, and corresponding at given points to *certain permanent states in the vegetable and brute creation*, may uniformly be traced in man at fixed periods of his embryonic and fœtal existence; and accordingly,—2, that vestiges in the adult heart of early arrested and merely temporary structures—such as those narrated by the author in this paper—record distinctly, in his opinion, the existence *of definite stages of embryonic and fœtal development in man*, through which stages he invariably passes towards his perfect adaptation for higher functions.

(*Part Second* of those observations—On the Permanence of the Foramen Ovale—is reserved for another paper).

The following Gentleman was elected a Fellow of the Society:—

James Dewar, Esq., Assistant to the Professor of Chemistry in the University of Edinburgh.

Monday, 1st March 1869.

Sir WILLIAM THOMSON, Vice-President, in the Chair.

At the request of the Council, Professor Allman gave an account of the Anthropoid Apes, chiefly with reference to specimens recently acquired by the Edinburgh Museum of Science and Art.

In taking cranial capacity as a ground of comparison between the Anthropoids and Man, he gave some measurements of skulls contained in the Museum. The capacity of the cranial cavity in the Gorilla skeleton belonging to the Museum is 29 cubic inches. Considerably larger gorilla skulls, however, have been measured. The smallest healthy adult human skulls in the Museum are those of two Andaman Islanders. Of these, one has a cranial capacity of 75·5 cubic inches, and the other a capacity of 72 cubic inches. Next to these comes a Peruvian skull; its cranial cavity measures 76 cubic inches. The smallest healthy adult human skull measured by Morton was also that of a Peruvian, whose cranial capacity mea sured only 58 cubic inches.

In taking the other points of comparison of the Anthropoid Apes with Man, it was shown how most of the alleged differences of conformation disappear on a strict examination; and the author defended the views of Huxley and those anatomists who insist on the development of the posterior lobes of the cerebrum and their associated structures in the Quadrumana, as in Man.

A question, however, still remains for determination. After eliminating all the tenable points of divergence, what value are we justified in assigning to the characters which still remain?

It is quite certain, as has been urged with great force by Huxley, after an exhaustive comparison, that in physical conformation Man approaches more nearly to the Gorilla and the Chimpanzee than these do to the lower Quadrumana. Must we, therefore, while the Gorilla and these lower Quadrumana are included in a common zoological order, unite Man with them as another member of that order?

He believed not. It had been already urged as an argument in favour of the unity and generally accepted limits of the order Quadrumana, that while the Gorilla graduates by intervening forms into the lower monkeys, there are no connecting forms yet discovered between Man and the Gorilla. He considered this argument, so far as it goes, a valid one, but another might be derived from a comparison of the Lemurs, or lowest Quadrumana with other Mammalian orders. Such a comparison will show that man is more widely removed from the higher apes than the Insectivora are from the Lemurs, and as long as the Lemurs are retained among the Quadrumana there will be less tenable grounds for admitting man into the same zoological order with the apes than there would be for admitting into this order the insectivorous moles and hedgehogs.

The relations here insisted on are rendered apparent by the following diagram, in which the Lemurs and the Gorilla are taken as the two extremes of the Quadrumanous series, and the close relation of the Insectivora to the series through the Lemurs indicated by converging arrows, while the less intimate relation of Man to the same series through the Gorilla is indicated by diverging arrows.

INSECTIVORA →← Lemurs, Monkeys, Gorilla ←→ MAN.

From these facts, the author found himself compelled to retain the zoological group BIMANA as a legitimately constituted order distinct from that of the QUADRUMANA.

But after all, it is not in any recognisable physical conformation, but in psychological phenomena, that the grand differences are to be sought for between man and even the most intelligent of the brutes; and the author argued, that though there be some intellectual endowments which are undoubtedly common to man and the higher brutes, there are others which are exclusively man's, which differ from those of the brutes not only in degree but in kind, and of which, after the most careful analysis, not even a rudiment can be detected in the intellectual phenomena of any animal below man.

It was maintained that a resemblance between certain acts performed by brutes, and others met with in man, may occasion an erroneous interpretation of the former, while a rigid comparison would show that the resemblance was only superficial and deceptive. Such, for instance, as the apparent faculty of conceiving the relation between cause and effect, the acts which so frequently seem to indicate a conception of causation in the lower animals being the result either of instinctive impulse or of suggestive association.

Among the faculties which the author thus regarded as eminently distinguishing man, there was one which did not appear to have hitherto obtained the attention it deserves. He alluded to what may be termed *imitative delineation* and *imitative constructiveness*, or the faculty of imitatively expressing the forms of objects by drawing and construction. While a faculty of imitating gestures and sounds is possessed by many brutes, and while *instinctive* constructiveness is almost universally found throughout the animal kingdom, the faculty of imitative delineation and imitative constructiveness is eminently a human one; we find it in the lowest and most undeveloped savage, and almost the very earliest evidence we possess of human intelligence—the intelligence of a period when man was as yet the contemporary of the mammoth, and when the reindeer extended its range into Southern Europe—is to be found in portraits of that mammoth and of that reindeer scratched upon fragments of their tusks and horns. And yet there is no physical obstacle to the exercise of this power by animals; the beak and the claw are implements as effective as the rude flint point of the savage, and there is nothing in the physical conformation of the Gorilla to prevent that flint point from becoming in his hand an implement of design.

The following Gentleman was elected a Fellow of the Society:—

Rev. H. CALDERWOOD, LL.D., Professor of Moral Philosophy in the University of Edinburgh.

Monday, 15th March 1869.

DAVID MILNE-HOME, Esq., Vice-President, in the Chair.

The following Communications were read:—

1. Motion of a Palladium Plate during the formation of Graham's Hydrogenium. By James Dewar, Esq.

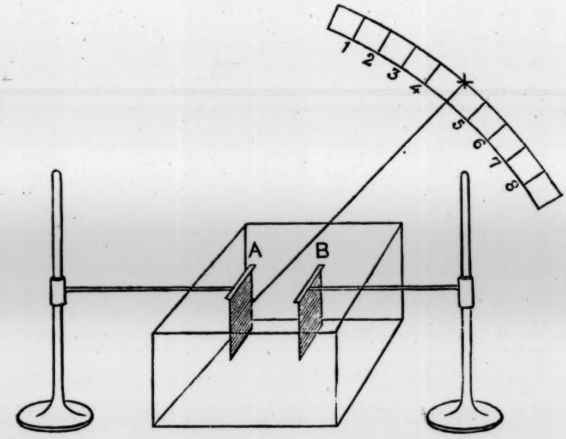
(Received 1st March 1869.)

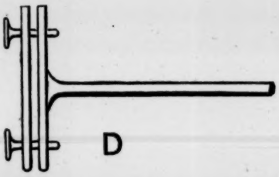
Graham, in continuing his exhaustive researches on diffusion, has recently examined the relation of gases to various colloid septa. The remarkable discovery of Deville and Troost of the permeability of platinum and iron by hydrogen at a red heat, he has expanded into a general examination of the relative rates of passage, at high temperature, of the various gases through different metallic septa. Further, he has proved that different metals have a specific occluding power over certain gaseous elements, retaining them in combination at low temperatures, although the absorption took place at a red heat. Of the many astonishing discoveries made during the course of these investigations, probably the most remarkable is the occlusion of hydrogen by palladium. This metal, whether in the form of sponge or hammered foil, when heated and cooled in an atmosphere of hydrogen, absorbed between six and seven hundred times its volume—increasing to the enormous occlusion of 982 volumes, when the metal used had been deposited by voltaic action. This occlusion of hydrogen, Graham has shown, can be easily effected at low temperatures by making palladium the negative electrode during the electrolysis of water. He has also shown that the metal, charged with hydrogen, has increased greatly in volume, and that its physical properties are entirely modified. So marked is the change in the physical, electrical, and magnetic properties of the combination, that the only class of compounds we can compare it with are the metallic alloys. In the occluded state the chemical intensity of hydrogen is increased, many reactions being effected by its agency beyond the power of the element in the free state. Graham, as a general result of his experiments, considers the occluded gas to exist in the form of a solid, with all the physical properties of a metal. During the course of an experimental exhibition of Graham's discovery, I noted several phenomena associated with the occlusion of hydrogen by palladium, when it is made the negative electrode during the electrolysis of water; and as they illustrate, in a new form, the results already arrived at by the Master of the Mint, with his permission I am induced to bring them before the Society.

If a palladium plate, used as the negative electrode during the decomposition of water, be arranged at right angles, instead of parallel to a similar platinum plate, the hydrogen in a short time is evolved at the edge of the palladium plate nearest to the platinum electrode—no trace of hydrogen coming from any other part of the plate. Gradually, as the saturation takes place, the hydrogen seems to travel slowly along the plate, and only after saturation is it freely evolved from the whole surface of the electrode. If we now reverse the current, so as to evolve oxygen at the palladium plate, immediately the nearest edge begins to evolve gas, the rest of the plate remaining tranquil, the evolution of oxygen moves along the plate in a gradual manner. This gradual transference depends on the time necessary to effect the occlusion, and on the relative intensity of the lines of force.

When a palladium plate, charged with hydrogen, is brought in contact with a platinum electrode freely evolving oxygen, the evolution of gas is immediately arrested over the entire surface of the electrode. The same plate, free from hydrogen, when brought in contact with a platinum electrode evolving hydrogen, shifted the evolution of gas only on the same side on which it was firmly pressed. In order to examine the action of mixed electrodes, the palladium plate was welded with a similar platinum plate into a V shaped electrode, when the apex of the combination could be placed in or out of the liquid. If the platino-palladium electrode is made the negative pole, hydrogen makes its appearance immediately on the platinum plate; no gas is evolved by the palladium for some time. If, after saturation, by reversing the poles, oxygen is thrown on the mixed electrode, no gas is evolved from the platinum, and when the gas began to be evolved, it appeared simultaneously on both plates. The same result is observed whatever may be the position of the compound plate relatively to the other pole in the liquid, relative distance from the other pole having no effect. This proves that the whole of the oxygen that ought to be evolved on the platinum is transferred by a polar chain, through the liquid, on to the palladium plate, so long as this plate contains occluded hydrogen. The presence of the strong electric current is shown by connecting the hydrogenised palladium with a platinum plate in an acid liquid, the circuit containing a galvanometer. If the apex of the V electrode is placed in the acid liquid additional phenomena are witnessed, depending upon which side of the compound electrode is next to the other electrode. If the platinum side of the V electrode is firmly clipped in a stand, a glass rod keeping the apex in the same position in the liquid, and if the palladium plate is next to the positive electrode, we observe the following change during the course of the hydrogenation. The angle of the V continually diminishes by the motion of the palladium towards the perpendicular, the hydrogen evolved coming only from the outer surface to the compound plate. After some time the plate returns to its original position, and would curve beyond it if the action was continued. If oxygen is now evolved on the compound plates, the first effect of the oxygen is to curve it beyond its first position, or to increase the angle of the V. If the palladium plate was furthest from the positive electrode, the first effect of the hydrogenation is to increase the angle of the compound plate by the palladium moving outwards; after some time it returns. Similar observations, as with the palladium clipped in stand, but made with the junction out of the liquid, showed a decided movement depending on the relative position of the plates. Seeing the palladium moved, although firmly clipped in a socket out of the liquid, it was evident the motion could be examined without the use of compound plates.

After devising several arrangements in order to examine with ease the motion of the plate, the following plan was found to be the best in practice:—

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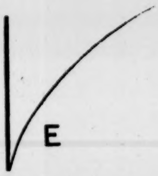
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The electrodes of palladium and platinum were firmly clamped in the little vice represented by D, and arranged as shown in the figure, where A represents the palladium and B the platinum. To the lower edge of the palladium plate a narrow strip of the same metal is fused by the oxyhydrogen blow-pipe; the strip is of such a length as to project above the level of the acid liquid when the plate is immersed. To the end of the strip of palladium a thread of glass is fused so as to have a radius in all of 40 or 50 centimetres; the arc of a divided circle of the same radius, on a piece of cardboard, is supported by a stand at the extremity of the index.

By this apparatus the small deflection of the palladium plate is greatly magnified, and the direction of motion well defined. Suppose the palladium plate, A in the figure, is connected with the negative pole of the battery, the glass index, after a short time, begins to move from left to right on the plane of the diagram, to the extent of 8 or 10 centimetres on the scale. As the saturation goes on, the index begins to move backwards from its first position, going towards the left even to a greater extent than its first deflection towards the right. Continuing the action, it again returns to near its original position. The power of being able to return to the position it had at starting seems to depend on the position of the plate, as regards the distribution of tensile strain, produced by rolling; at least, after repeated use the plate lost the power of returning, after having passed towards the left. If the plate, after saturation, is connected with the positive pole of the battery, the first effect on the index is to move quickly towards the left, then to return to where it was—this double motion taking place before any gas makes its appearance on the palladium. If the platinum electrode B is placed on the opposite side of A, and the saturation of the plate repeated, the index goes through the same series of positions, but the direction of motion is reversed. The direction of motion depends, therefore, on the relative positions of the electrodes, but is constant for the same position. This is easily shown by allowing the index to commence its motion, say from left to right; then, by moving the positive electrode to the other side of the palladium plate, the motion immediately commences in the opposite direction, although the saturation was far from being complete. The motion of the index, when oxygen is thrown on the hydrogenised plate, depends also on the position of the electrodes. The index has also a motion at right angles to the plane of the scale, the resultant motion being compounded of the separate flexures of the plate. Many other devices could be used to show the motion, such as a plate bent into the form of a cylinder with a narrow channel left between the two edges, which should shut and open alternately, according as the positive electrode is without or within the cylinder.

Graham has shown that the formation of the alloy of hydrogenium and palladium is attended with an enormous increase in the volume of the metal. He found that a wire of palladium 100 millimetres in length became 101·5 millimetres when saturated with hydrogen. Now, if a uniform hydrogen atmosphere surrounds a symmetrical piece of palladium, there is no reason why it should penetrate with a greater rapidity one surface rather than any other. But if the absorption is not uniform on all the surfaces, from want of uniformity in the hydrogen atmosphere, the surface absorbing must produce a flexure of the plate from the expansion of the metal. If a thin plate of this rigid metal can be so arranged as to induce absorption on one side rather than the other, then, as a necessary consequence, the plate will become convex on the side where the greatest relative absorption is taking place; and as the saturation approaches uniformity, the convexity should disappear, the plate regaining its original form if the elasticity of the metal is not changed during the action. A plate of palladium, when it functions as the negative pole during the electrolysis of water, is subjected during the course of the action to the supposed non-uniformity of the gaseous atmosphere—if the surface of the plate is parallel to a similar platinum electrode. The amount of chemical action effected by the unit surface of the electrode, and its distribution, depends upon the position of the plate relatively to the lines of force emanating from the poles. Now, of the two surfaces of the palladium plate, the surface next to the positive pole has the greatest concentration of the lines of force, and therefore the greatest evolution of hydrogen takes place on this surface, so that the quantity of alloy formed in the first instance is in excess of the amount produced on the other side. The plate, from the great expansion on the outer side, becomes convex, until the progression of the action from the other side is able to compensate this flexure by a corresponding expansion, thereby bringing the plate to its original form. But I have already explained how this backward motion goes beyond the original position, producing a flexure in the opposite direction, only in some cases returning to its normal shape. This, in all probability, arises from the combined effect of expansion and compression. Graham has shown that this tenacity of the alloy is considerably diminished as compared with that of the palladium, so that in the first flexure of the plate the expansion has to compress the rigid palladium, whereas, when it begins to return, the compression is effected on the less rigid hydrogenium already formed on the other side, the elasticity of form being also probably relatively small. This is the general explanation of the motion of the plate, but it must be remembered that the smaller flexures produced by different forms and positions of the electrodes are the result of non-homogeneity or excessive strain. This is one position, at least, of the palladium relatively to the other electrode, where the plate should have no lateral motion—that is, when it is at right angles to the surface of the positive plate; but all the attempts made with the small palladium plate at my disposal failed to prevent lateral motion, probably from want of uniformity of surface producing different rates of penetration.

Effect on the Current during the Formation of the Hydrogenium.

In order to determine the effect on the current during the occlusion of the hydrogen and its reoxidation, two Bunsen's cells were connected, through a tangent galvanometer, with a plate of palladium and platinum as poles in a cell containing acidulated water. The intensity of the current was determined—1st, during the decomposition of the water, when the palladium pole evolved oxygen; then during the absorption of hydrogen, when the current was reversed; and lastly, when the oxidation of the occluded hydrogen was taking place.

	PALLADIUM. Positive Pole.	PALLADIUM. Negative Pole.	HYDROGENIUM. Positive Pole.
Angles on tangent galvanometer,	23°·5	21°·5	40°·3
Tangents, . .	0·4348	0·3939	0·8541

The diminution in the intensity of the current during the formation of the hydrogenium arises from the strong current, generated in the decomposing cell by the secondary polarity of the electrodes, acting in the opposite direction, whereas the oxidation of the hydrogenium reduces a current acting in the same direction as the battery. The intensity of the current during the oxidation of the hydrogenium is nearly doubled, so that if we consider the resistance in the circuit to remain constant, the additional electro-motive force added by the oxidation of the hydrogen is equivalent to two cells of Bunsen. The great increase in the intensity of the current during the oxidation of the hydrogenium may be shown in the following manner:—Use two palladium plates in the decomposing cell, with index to show the motion of the plate attached to each, as in the figure formerly given, and include in the circuit a commutator and a fine spiral of platinum wire. During the occlusion of hydrogen the platinum spiral may be made of such a length as to remain dark, the motion of the index proving the absorption of hydrogen. If the direction of the current is now reversed the spiral of platinum becomes red hot, the index moving rapidly back to its original position, while the index of the other plate begins to move. The oxidation of the occluded hydrogen is the limit to the brightness of the platinum spiral, so that a reversal of the current produces a renewed brightness. By this arrangement we keep both indices moving along the scale, and the platinum spiral alternately bright and dark. If the electro-motive force is really equal to a Bunsen's cell, this arrangement must produce a current far more intense than any similar gas-battery, where oxygen and hydrogen are the reacting elements; but as the resistance in the circuit might vary, several indirect experiments were made. When a palladium plate, saturated with hydrogen, was associated with a platinum plate in an acid solution of permanganic acid, and connected through a voltameter, the arrangement could decompose water. A similar result was obtained when a platinum plate coated with platinum-black saturated with oxygen was employed; but the action in this case was very slow, and sometimes did not succeed. A platinum plate covered with peroxide of lead was opposed to the hydrogenium; the combination decomposed water with facility. Grove found two pairs of his gas-battery could effect a slow decomposition of water, and a single pair did as well if the oxygen was replaced by peroxide of lead. (The intensity of palladium and peroxide of lead combination must render it particularly well adapted to form secondary piles of great intensity, by substituting it instead of a lead plate in the arrangement devised by M. G. Planté). The transformation of gaseous hydrogen into the occluded state would seem to have little effect in reducing its total chemical energy, so that the occluded hydrogen must retain a relatively large proportion of the total gaseous energy in a potential form. If we compare the occlusion of gases to work done on the gas, the elaborate researches of Joule and Thomson on the "Thermal Effects of Fluids in Motion," would lead us to believe that hydrogen of all gases would in this new condition retain the greatest amount of its original store of energy. But before a just comparison can be made with the results of Joule and Thomson, careful determinations must be made of the electro-motive force, latent heat, &c., of hydrogenium. Professor Tait has determined by a new process the electro-motive force of platinum and palladium covered with oxygen and hydrogen, and the result will be communicated to the Society in a short time.

2. Some Observations on Free, An-atomic, or Transmissible Power. By R. S. Wyld, Esq.

This is an abstract of the first of two papers on the subject, prepared for the Society.

Physical bodies may be held, in accordance with chemical science, to consist of aggregations, either of material atoms, or of atomic circles, or centres of force.

There are certain exhibitions of physical power observed in connection with those atomic bodies, the laws and actions of which are in the highest degree worthy of study. Mr Wyld calls power exhibited in this way, free an-atomic or tranmissible power.

Mr Wyld called attention to seven exhibitions of this free power, viz.—

1st, The attraction of gravity; 2d, cohesive power; 3d, the power of chemical affinity; 4th, animal power; 5th, the momentum of moving bodies; 6th, the electric force set free on the mechanical disintegration of quartz and many other crystals; 7th, the force obtained alike through the decomposition, the dissolution, and the combustion of simple and compound bodies.

The consideration of the nature and source of animal power Mr Wyld reserved to his second paper.

In the present paper Mr Wyld directed attention to the *momentum* or force of moving bodies, and to the law of its transmission from one body to another, as illustrated in the case of one rolling ball hitting another and imparting its force to it—and in the case of those atmospheric and ethereal vibrations which affect us with the sensations of sound and light.

When I roll a ball along the ground I communicate force to it; this force carries it forward till it encounters a body at rest, to which it communicates this force, and the force which came from me, may thus be transmitted or handed over, from ball to ball, through a lengthened series, subject only to such decrease as may arise from friction or other accidental obstructions.

Mr Wyld called attention to the circumstance—first, that the balls successively received something which we call force; second, that it is force which causes their movement, and not their movement which gives them their momentum or force. Their movement, however, seeing it is the result of the force, may be taken as a just measure of the force applied.

Another instance of the transmission of force we have when we direct, what has for convenience been called the electric or galvanic fluid, through wire conductors. The transmission of this manifestation of force may be explained on nearly the same principle as the transfer of the *momentun* of moving bodies, and of the mechanical vibratory force transmitted from molecule to molecule of the ethereal *medium*, which vibratory force we call light, and which reaches us after a passage of more than ninety-one millions of miles.

Mr Wyld considered these to be instances of the action, and transmission of what may be called free, an-atomic, or transmissible power, which is not to be viewed as a substance or fluid, but either as an imponderable immaterial agent, or simply as *the action of an unseen cause.*

Neither the nature of its origin, nor the nature of its transmission, nor the variety of its actions and operations, permit us to consider it as a substance. When we disintegrate crystals, when we separate the parts of fluids by evaporation, when we dissolve metals, or decompose compound bodies, organic or inorganic, we seem to obtain that force which held their parts together, in the form of free transmissible power. To this power we can by certain arrangements give a definite direction, and can transmit it through wire conductors. We can thus make it available for the production of many of the most important natural phenomena, for instance—

1. The production of intense artificial light.

2. The production of heat.
3. The decomposition of compound bodies.
4. The volatilising of metals and other bodies by the sheer violence of its movements.
5. The production of magnetic attraction.
6. When transmitted through the animal frame it overpowers our natural voluntary movements, and produces spasmodic muscular contractions.

To these different phenomena, for purposes of convenience, we give different names, but they are all the action of the same agent, viz., of power operating under different circumstances.

We very much simplify and clear up our conceptions of nature when we attend to these two facts—first, that every change observed in the physical world,—whether effected by natural or by artificial means, and whether connected with animal or vegetable living organisms, or with inorganic matter, may be described as a movement either of physical bodies in mass, or as a movement of their constituent parts or atoms; and second, that all these movements are effected by free an-atomic power, and by the transmission of it from one body to another.

Mr Wyld further summed up his views thus—

1. In the physical world we have a manifestation of power working uniformly according to physical law, *i.e.*, it is measured in amount, and it is fixed in its modes of action.

2. Physical power we ascertain by an examination of physical phenomena is subject neither to augmentation nor to diminution. Were it not so the world would be entirely different from what we observe it to be.

3. Power in all physical operations is transferred from one object to another, but is never lost.

4. We may regard physical power as an immaterial agent, or we may be satisfied to consider it simply as a mode of action brought about by a *cause unknown*. But whether we view it as an agent or as an action, and in whatever way we may account for its existence, it is evident that as it conducts every change in the physical world, it must act according to invariable physical law.

5. Physical power manifests itself in two distinct forms—namely, in the form of atomic bodies, which are discoverable by the senses,

and which consist of aggregations of atomic circles or centres of force; and in the form of free an-atomic or transmissible power which is not discoverable directly by the senses, but is known only by its effects on atomic bodies. The question whether the chemical atom is a material atom, or is purely dynamical, does not affect the truth of the writer's statements.

6. The mind seems conscious of possessing power, and of being able to exercise it for the production of physical movements. It has evidence of this when it exerts itself in the production of those muscular efforts which are subject to the control of the will. The mind is thus the agent in the production of voluntary movement through the free transmissible power which it sends to the muscle, as will be explained in the subsequent paper on this subject.

7. Free power effects the various important physical phenomena alluded to, *e.g.*, the production of motion—and the continuance of it as momentum, on which depends, not only the movements of the earth and planetary system, but the transmission of light and sound as above explained.

Mr Wyld explained that by the words physical law he meant to express simply the invariable modes of action observed in physical phenomena. The existence of action, however, always infers the existence of an agent or actor. This is not the most suitable place to inquire regarding the origin or cause of power, but it will be admitted that we discover nothing in atomic bodies to account for its existence. These seem rather to be the subjects of power than the cause of it, for all their movements and changes seem regulated and caused by it. They are therefore quite insufficient to account for it, or to explain it.

This inability to discover a visible cause for the laws of nature compels us to believe in an invisible cause, adequate to account for them. When, therefore, we discover power acting in the production of order, beauty, and enjoyment—and when we recognise ourselves as moral and intelligent beings brought into close connection with this physical system, we are drawn all but irresistibly to the conclusion that physical power is the sustained action of a mighty Being, possessed of the self-consciousness and intelligence with which we find ourselves to be endowed.

3. On the Practical Application of Reciprocal Figures to the Calculation of Strains on Framework. By Professor Fleeming Jenkin.

4. On a New Synthesis of Ammonia. By A. R. Catton, Esq., late Fellow, and P. T. Main, Esq., Fellow of St John's College, Cambridge.

It having been shown by one of us that formic acid is produced by the union of carbonic acid and nascent hydrogen, it occurred to the authors to try whether other gases might not be made to unite directly with nascent hydrogen. Such experiments gave the prospect of being of especial interest in the case of nitrogen, as it was possible the synthesis of ammonia might thus be effected by the direct union of nitrogen and hydrogen.

With this view pure nitrogen and aqueous vapour were passed over sodium. The nitrogen was prepared in the usual manner, by passing atmospheric air over heated copper, and was freed from ammonia by passing it through sulphuric acid. Not a trace of ammonia, however, was obtained in this way. When, however, nitrogen and aqueous vapour were passed over heated magnesium ribbon, a very appreciable quantity of ammonia was produced, and the quantity appeared, within certain limits, to be greater the higher the temperature to which the magnesium was heated. The ammonia was recognised in the usual way—by the smell, by its browning considerable quantities of turmeric paper, and by the formation of the double chloride of platinum and ammonium. The theory of this reaction evidently is, that the magnesium decomposes the aqueous vapour, and that the hydrogen thus produced, when in the nascent state, combines with some of the nitrogen, and forms ammonia. Only a small part of the nitrogen, however, is in this way converted into ammonia. One cause of this evidently is that the magnesia produced during the reaction forms a coating on the surface of the magnesium ribbon, and so protects it from further action. For this reason it has occurred to the authors that larger quantities of ammonia may be obtained by using powdered magnesium, either by itself or mixed with fine sand, as in Larkin's magnesium lamp. The authors, however, have no hope of modifying the process in such a manner as to convert any considerable proportion of the nitrogen of the atmosphere into ammonia, a problem of the highest practical importance. Nevertheless, the formation of ammonia in this way is of considerable theoretical interest, especially when viewed in connection with the source of the ammonia in nature, a question to which no satisfactory solution has yet been given.

We purpose, when circumstances permit, to continue our experiments on the subjects indicated in this paper.

The following Gentlemen were elected Fellows of the Society:—

Principal Sir Alexander Grant, Bart.
Captain T. P. White, Royal Engineers.

The following alteration proposed by the Council on the Law relative to the Election of Honorary Fellows was adopted by the Society:—

Law XII., lines 6 and 7, in place of the words, "and printed in the Circular for the meeting at which the ballot is to take place," read, "and printed in the Circulars for two ordinary meetings of the Society, previous to the day of election."

Monday, 5*th April* 1869.

Dr CHRISTISON, President, in the Chair.

The following Communications were read:—

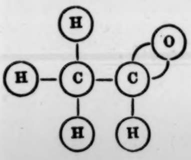
1. On the Present State of the Sun's Distance Question—*continued.* By W. Petrie, Esq. Communicated by Professor C. Piazzi Smyth.

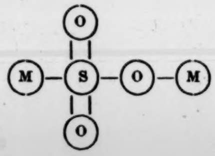
This paper is a compilation and discussion of all the best determinations of the sun's mean distance and parallax within the last few years, and up to the present time. The comparative weights to be given to the different observations or results are entered into at length, on principles which are stated, and a final mean of the whole is arrived at, giving for the solar parallax 8·″877. This is then compared with the result of the so-called Great Pyramid Sun Distance, which, combined with the best modern determination of the size and shape of the earth, gives a parallax of 8·″876.

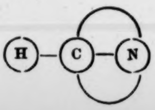
The direct results of modern science for the solar parallax vary anywhere between 8·″80 and 8·″96; and to assist in apprehending the present state of a very contested question as to one of the most important of all physical facts, Mr Petrie added to his paper two very instructive diagrams, in one of which the chief data were arranged chronologically, and in the other quantitatively.

2. On Chemical Structure. By Dr A. Crum Brown.

In this paper the author drew attention to the nature of the process of *Chemical Exchange* (including substitution, double decomposition, and some cases of direct addition and subtraction), as a process by which the *number* of relations in which any given atom stands is unaffected. He pointed out the connection between this process and the notion of chemical structure, and discussed the nature of those chemical processes in which the number of relations of an atom is increased or diminished. He concluded by some remarks on the ambiguous structure of such bodies as aldehyde, the sulphites, and hydrocyanic acid, which from some points of view may be represented as—







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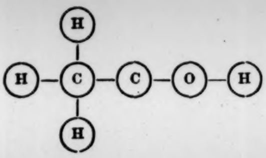

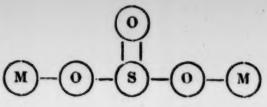

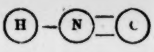

3. Observations on the Temperature of Newly-born Children. By T. J. Maclagan, M.D., Dundee. Communicated by J. Matthews Duncan, M.D.

That the temperature of the child is not the same as that of the adult has long been a generally acknowledged fact, but wherein and to what extent it differs is a point on which definite information is wanting. With the object of determining this point, the author took advantage of the opportunities afforded by a residence in the Edinburgh Maternity Hospital, to note the temperature of a number of children at the time of birth, and at frequently repeated intervals during the first few days of extra-uterine life. The result of these observations was to show that the child at birth partook of the temperature of the mother—that as soon as it commenced its separate existence the heat imparted by the parent was no longer maintained, but was rapidly lost, till, in a few hours (the exact period varying in different cases), the thermometer indicated a temperature one, two, three, or even six degrees below the normal standard of the adult. A rise then took place, and generally within twenty-four hours after birth the range might be regarded as normal. This normal range of the child, however, was about one degree lower than the adult range of health. The rapid fall which was shown to take place immediately after birth, was believed to be due to the refrigerating influence of the external air on the blood in the lungs, the nervous influence which is requisite to give to the respiratory act its heat-producing effect, not being in full force at the time of birth. The lower range which existed during the first few days, after the primary temporary depression had been recovered from, was believed to be caused, in part at least, by the defective purification of the blood, consequent on the patent condition of the foramen ovale and ductus arteriosus.

In delicate and premature children all the peculiarities indicated were observed in an exaggerated degree.

4. On the Growth, Development, and Situation of the Human Fœtal Heart. By Professor Macdonald.

The earliest condition of the embryonic vascular system, as described by Wagner and other embryologists, consists of a venovascular chain of sinuses along the ventral surface of the serous or animal lamina of the embryonic germ disc, which, being suddenly arrested by a large projection of the germ vesicle at the anterior part beyond the vascular and mucous lamina, causes a stagnation in the form of a conical sac, whose apex points forward below the head of the embryo at that time consisting of the mesocrane and procrane, with the visceral segments of the face-kist, and exhibiting three facial clefts.

1. The ophthalmic, under the procrane, forming the roof of the orbit, and completes its floor resting on the antrum highmorianum.
2. The olfactory cleft, the nasal passage beneath the antrum, the ethnoid and turbinated bones, its floor being the hard palate.
3. The oral cleft, below the palate, forming the roof of the mouth, while the hyoid and tongue form the floor, and the maxilla and muscles of the cheek complete the cavity of the mouth.

I. As soon as the conical sac of the venous sinuses and azygeal veins from the chorda centralis (the future spinal column) extend to the upper angle of the first formed embryonic heart, where two tubes or inferent veins enter from the lower angle of its base, a single efferent tube—the ductus venosus—leading backwards, and sending forwards from the umbilicus a vein on each side (in birds towards the circular sinus, from which a fringe of minute capillaries extend below the chorion). In the capillary area, where the veins and arteries communicate, the venous blood becomes oxidised, and returns by the arterial area to the embryo; the minute arterial rootlets becoming larger and larger, till the blastine artery from each side enter the lower part of the embryo above the highly upturned coccyx, the lower orifice of the future umbilicus, when the abdomen is closed. From this point these arteries (the future umbilical of the fœtus) descend to the iliacs, which unite opposite the promontory of the sacrum, and carry the arterial blood upward along the chorda centralis, as high as the fovea cardiaca, or pharyngeal hollow, from whence the double aortæ each divide into two terminal branches, which unite behind the base of the heart to form the arterial aortic bulb, quite unconnected with the cavity of the heart, the top of the bulb seen rising higher than the heart, has misled embryologists to fancy it was a part of a twisted tube, which has sometimes been described as the first form of the embryonic heart. Pander, Prevost, and Dumas, as well as Wagner and Allen Thomson, describe the first heart as a conical sac, having its apex anterior beneath the head of the embryo, with two inferent veins entering from above, and only one efferent tube, the ductus venosus. Wagner mentions a certain amount of motion among the blood-discs, previous to the contraction of the conical heart, having only a single cavity. It is at first transparent and membranous, but contractile, and filled with a yellowish or pale orange fluid, the plasma or liquor sanguinis. As soon as the punctum saliens in the base of the heart starts its contraction, its fluid is forced down the ductus venosus to the oxidising area of the chorion, where it is fully arterialised, and follows the course, already shortly described, to the aorta, its terminal branches, forming the aortic bulb, terminate in the carotid and subclavian arteries to the head, upper trunk, and extremities. From thence the blood, reduced to a venous condition, is returned by the jugular and subclavian veins forming the superior venæ cavæ, which flow into the single cavity of the primary heart. The thin condition of its transparent walls might lead us to view it as analogous to the lymph heart of the frog and tail of the eel, so well described by Mr Wharton Jones, F.R.S., in a communication published in the last volume of the Philosophical Transactions, forcing on a column of dark venous blood discs.

II. Soon after the blood has circulated once or twice, there is a ventricle added to the base of the auricle, which is then perforated by the auriculo-ventricular orifice. Still there is only the same outlet for the venous blood from the heart, which is, during fœtal non-breathing existence, entirely connected alone with the venous circulation.

III. The next change in the structure of the heart is the dividing the ventricle by a muscular septum, which, till it is complete, allows the venous blood to enter freely into both ventricles (a system which continues in some reptiles), from which it is instantly returned to the auricle by their systole, and forced down the ductus venosus to be oxidised and returned as arterial by the umbilical arteries into the iliacs, and upwards by the aortæ, as already described.

IV. After the completion of the ventricular septum there commences a septum in the auricle, never completed for at least a year after birth, leaving the foramen ovale soon partially covered by a valve. Even subsequent to the formation of the quadrilocular heart of the fœtus, still the ductus venosus is the only outlet of venous blood sent to be oxidised and returned by the arteries to the aortic bulb for circulation. The foramen ovale (rationally explained) permits the free passing of the blood to and from the ventricles, and readily explains what Dr Churchhill could not—" That the pulse detected by the stethescope, when applied to the maternal abdomen, indicated twice the rapidity detected at the cord in cases of prolapsus or turning." The systole of the auricles preceding that of the ventricles may be detected by the ear; but being immediately followed by the stronger contraction of the ventricles tilting the apex against the sides of the chest, as in the adult, impresses the finger when applied to the cord with half the rapidity of the pulse indicated by the stethoscope.

V. Towards the close of pregnancy a much greater change is being inaugurated preparatory to the inflation of the lung-cells. The very beautiful demonstration by Dr Tonge by a well-conducted series of experiments on the aortic bulb of the chick, in a paper communicated to the Royal Society last year by Professor Beale.

Dr Tonge describes, towards the close of incubation, that there may be traced, extending from the upper left angle of the bulb, below the entrance of one of the left terminal branches of the aorta, the commencement of a fine film of its lining membrane descending diagonally to the lower right corner (the right aorta and its terminal branches having disappeared). This division into two tubes he describes as being closed by three semilunar valves, preventing the flow of the arterial blood into the ventricles.

While these changes are going on in the bulb, the right ventricle pushes a horn over the auriculo-ventricular septum and auricles, from the right margin of the heart upwards to the left side of the bulb, and passing behind it ramifies into right and left pulmonary trunks. The left ventricle, in like manner, pushes its horn behind the mitral valve, under the right auricle, and, rising over the upper part of the aortic bulb, carries off the innominata, carotid and subclavian arteries, as well as crushing off the last upper left terminal branch of the aorta (leaving a small portion, which quickly becomes merely tendinous, hitherto fancied to be "the ductus arteriosus," which has really no existence) between its own trunk and that of the right pulmonary artery, forming the arch of the aorta, it continues its course by the left embryonic ascending aorta (as soon as the first inflation of the lung-cells permits the flow of blood from the ventricles by their new outlet). The now arterialised blood flows down the thoracic and abdominal aorta to be distributed through the system.

The following Gentleman was elected a Fellow of the Society:—

J. WILSON JOHNSTON, M.D., Bengal.

Monday, 19th April 1869.

PROFESSOR KELLAND, Vice-President, in the Chair.

The following Communications were read:—

1. The Mean Pressure of the Atmosphere, and the Prevailing Winds for the Months and for the Year. Part II. By Alexander Buchan, Secretary of the Meteorological Society.

In Part I., read 16th March 1868, in which was discussed the Mean Pressure of the Atmosphere over the Globe for July, January, and the year, the method by which the Isobaric Charts were constructed was detailed at length. Since March 1868, valuable additional information has been obtained from Australia, New Zealand, Tasmania, Africa, South America, the west coast of North America, Iceland, and from a few isolated stations in Europe and Asia. The period for the British Islands has been extended so as to include the eleven years from 1857 to 1867.

Part II. gives the complete set of Charts for the twelve months and for the year. In this Part the prevailing winds were shown from good averages collected or calculated for upwards of two hundred places over the globe. The general result is that the surface winds of the globe flow round and inwards upon regions of low pressure on every side from which observations have been obtained, and that surface winds flow out of spaces of high pressure in every direction. This *outflow* of the winds from regions of high pressure, and *inflow* upon regions of low pressure, may be explained by the principle of gravitation. Indeed, so strongly is this force marked, on comparing isobaric lines with prevailing winds, that if there be any other force or forces concerned in setting the winds in motion, they must hold a very subordinate place. The influence of a mountain range in diverting aerial currents from their normal courses was illustrated by the prevailing winds in Norway; and an explanation was offered of the anomalous direction of the winds on the coast of West Greenland.

The relation of the data, graphically delineated on the charts, to climate was pointed out; for since winds bring with them the temperature of the parts of the earth's surface they have traversed, the charts may be regarded as furnishing the key to the climates of different countries. Their relation to the rainfall of the different months of the year was adverted to. Thus, by a careful study of the isobaric lines, and the prevailing winds, in connection with the isothermal lines, the climate of any region may be more closely approximated to than has hitherto been possible.

It was pointed out that the position of the isobaric lines in the different months appears to be entirely determined by the sun and the geographical distribution of land and water; and since these lines, in their turn, determine the climates of the globe, there is here evidently a principle applicable not only to the present state of the earth, but also to other distributions of land and water in past times; in other words, there is here a principle of the utmost importance to the geologist in attempting to account for glacial and warm periods through which the climates of Great Britain and other countries are known to have passed. If this conclusion be just, we are now in a position to give an approximate numerical statement of Lyall's idea of the effect produced on climate by the displacements of continents.

2. On the Rectangular Current Theory of Storms, illustrated by two Storms which passed over the United States, from the 13th to 19th March 1869. By Robert Russell, Esq.

The author's former views on American storms were first alluded to—*i.e.*, that the phenomena could only be accounted for on the supposition that there were two distinct currents. Instead of these being parallel, they were more nearly at right angles to each other. The southerly current on the eastern axis of storms brought up heat and moisture from the Gulf of Mexico, causing the barometers to fall. The west or north-west wind, on the other hand, cleared the southerly current away, causing the temperature everywhere to fall and the barometer to rise.

The storms under review were then examined by M. Le Verrier's mode of laying down isobarometric lines on charts, but for every tenth of an inch of pressure instead of two-tenths. The southerly current was shown to have distinct lines of contour and order from the other—the west or north-west at right angles to it.

The minimum line of the barometer where the currents meet, or where the west flowed into the southerly, was described and pointed out; the barometers obtaining their lowest reading, and thermometers their highest on that line, on any latitude, from the Lakes to the Gulf of Mexico. As formerly defined, in the Proceedings of this Society, "the latitudinal line of minimum barometer represents that space where the air, from the surface of the earth to the top of the atmosphere, is warmest on any latitude, and consequently lightest."

The charts of 13th and 14th March 1859 were first exhibited, showing that thunder storms with rains prevailed up the Mississippi valley, as far north as the southern border of the State of Michigan. At the same time a severe snow storm from the north-east prevailed over Minnesota, Northern Wisconsin, and Northern Michigan—a foot of snow falling over a large extent of country. The line of minimum barometer was greatly curved, or, what is the same thing, stretching from south-east to north-west in its northern part. The remarkable analogy between the main phenomena of this storm and that of the "Royal Charter" storm of 1859, was pointed out by the author reading a passage which he had formerly written regarding that storm, and merely substituting American dates and places for British.

The chart of 15th showed that the cold west wind, which was first felt in Texas at 9 P.M. of the 13th, and was at first travelling faster in the south than the north, had swept the whole country as far east as St Johns in South Carolina, and northwards as far as Oswego at the east end of Lake Ontario. The line of minimum barometer was then nearly straight from St Johns to Oswego, cold winds prevailing on the west, and warm on the east side of it.

The author then drew attention to the phenomena of calms that appear in the front and rear of all the American storms, as well as our own. The calms stretching southwards from Toronto, on the night of the 13th March, advanced eastwards at the rate of 10 to 12 degrees of longitude a day. On the morning of the 15th the calms were east of Nova Scotia. At the very same time another series of calms was produced on the west from Texas north to the west end of Lake Superior. Frost now visits Texas, where thirty-four hours before the thermometer stood at 82° in the shade. This series of calms was the forerunner of another and more severe storm then to the west of them. On the morning of the 16th the central axis of the calms was over the 85th longitude, having again advanced 10 to 12 degrees in twenty-four hours. The calms, then seen where there were a multiplicity of stations, showed that they were of the form of a pyramid, rounded at the top, but wide at the base. Along the shores of the Gulf of Mexico the region of calms was at least 700 miles broad, but not more than 200 miles on the Lakes. The advance eastwards of these calms from day to day, with the storm to the west of them, was then traced.

The storm on the west of the calms of the 16th was traced out. Charts were exhibited of the morning of the 18th and night of the 18th, showing its progress from west to east over the States, and that the west wind advanced faster over the Southern States than the Northern. As a consequence, the minimum line of barometer was largely bent over the Eastern States, stretching from north-west to south-east—this direction being exactly reversed from that of the morning of the 15th March.

The author then pointed out the relation which the winds to the west of line of minimum barometer bore to the winds on the east, according to the direction of this line with respect to the meridians.

1*st*, When the minimum line is straight, or nearly so, on the meridians, as on morning of 18th March, the winds change from a southerly or easterly direction to west or north-west. This holds true as far to the northwards as the pressure decreases from south to north on the line of minimum barometer, as it did over an extent of the line, on the morning of 18th March, for upwards of 800 miles. Under these conditions, a calm or lull of the wind occurs along the line before the wind changes suddenly to the west or north-west.

2*d*, On the northern border of the storm, where the line of minimum barometer is curved, or lying from south-east to north-west, as in Scotland during "Royal Charter" storm, the wind does not calm down, but veers from north-east to north and west.

3*d*, On the southern border of the storm, when the line lies from north-east to south-west, as in common in the valley of the Mississippi west of the river, the winds are more northerly there and along the Gulf than in any other part of the United States. When this direction of the line occurs in Scotland, we are liable to such eruptions of northerly winds as wrecked the "Ivanhoe" in December 1867.

4*th*, When the minimum line of barometer on the southern border of the storm lies from south-east to north-west an opposite state of things occur. The winds do not lull or veer at first; the cold current from the west rushes in behind the south-westerly warm winds, and causes the temperature to fall and the barometer to rise. The terminating winds on the east and west sides of the minimum line on the 15th and the 19th March were contrasted in this respect.

The relation as well as want of conformity in contour between the isobarometric lines of the cold west winds and those of the warm southerly winds were pointed out. The phenomenon of the kneeing-in of the isobarometric lines on the west of the minimum line was exhibited. The phenomenon was parallel in principle to that formerly shown by the author, as existing in the south of England and north of France on morning of 3d December 1863.

The author then pointed out the extraordinary different results that were obtained in measuring the rate at which storms progressed, but taking either the minimum line or minimum point. The French, and indeed the common method, is to take the minimum point, while Espy took the minimum line. Neither the one nor the other can be relied on to show the actual rate of progress of the storm. Taking either of these methods, the storm of the 14th advanced eastwards from Border Plains in Iowa to Oswego in New York State, about 900 miles in twenty-four hours, or upwards of 37 miles an hour. That of the 17th, by either of these methods, from Dubuque, in Iowa, on the Mississippi, to a little to the east of Lake Michigan, 240 miles, or 10 miles an hour. The further progress of this storm by either of these methods was 20 miles an hour. The author then maintained that the rate at which the calms shifted their place in front and rear of these storms furnished the true measure of their rate of propagation.

The author then gave his views as to the mode in which storms are propagated. The idea still maintained by the French, as well as by most meteorologists, that the falling barometers, high temperatures, and rains on the east side of storms, were actually translated from west to east, was quite indefensible. It was argued that the calms along the Gulf of Mexico, which were propagated in front of storms, at the rate of nearly 600 miles a day, or about 25 miles an hour, could not possibly be imagined to travel or be pushed along from west to east. If they were so, there could be no calm. So the red lines on the charts, showing the falling barometers and rains, like the calms, apparently travel from west to east. There can be no translation however. These phenomena are the effects of causes which are acting on the spot. On the morning of the 18th the southerly winds to the east of the line of minimum barometer, over an immense area, were all light, mixed with calms, and from almost every point of the compass. They could not possibly be in a state of translation from west to east at the rate of 20 miles an hour. The explanation is, the southerly winds bring in moisture, which is condensed by the cold of expansion, as the air over the region, swept by the warm southerly winds, ascends. It is a process which once begun tends to perpetuate itself. An inch of rain on an average fell over an immense area. According to Espy and Tyndall, as much force would be evolved on 50 square miles of any of these States (a mere spect on the charts) than the 100,000,000 of tons of coals that Great Britain raises in a year. The vapour, as it becomes condensed in rains, converts the atmosphere into a vast caloric engine, and produces vast effects. Twenty-five miles of calms on the west side of the calm region are every hour converted into easterly winds, which blow towards the line of minimum barometer, and 25 miles of calms are produced every hour on the east side; and besides, the air, as seen in chart of 16th March, is tossed over the calms, as an upper current from the west, and as it cools by radiation, descends and supplies the cold and dry winds that blow in the rear of the minimum line of barometer on the west side of the previous storm.

The rate at which the calms are propagated along the latitudes is the true index of the rate of a storm's progress. Whatever may be the particular character of the disturbance within, the calms on the east and on the west contain the whole body of the storm within their bounds. Their rate of propagation is the true rate of that of the disturbances within. With all deference to Espy, storms must be propagated faster along the south; for so long as the central axis of the calms is meridional, it must move more rapidly in the south, for the simple reason that the meridians are wider there.

3. On the Boulder-Clay of Europe. By D. Milne-Home, Esq.

It was explained that this deposit, known in Scotland as Till or Boulder-Clay, prevails also in Ireland, the Isle of Man, England (north of the Thames), Denmark, and Sweden, though much less abundantly in these last countries. It exists also in the Hudson's Bay districts, and at the south extremity of South America.

It had been a subject of perplexity to geologists ever since attention was drawn to it, fifty years ago, by Sir James Hall of Dunglass, whose papers are in the Transactions of this Society.

About the year 1840 a theory was started to account for the boulder-clay, and other phenomena allowed to be connected with it, by the action of glaciers.

At first, local glaciers were proposed; but latterly there seemed to be a disposition among Scotch geologists to adopt the startling speculations of Agassiz, that a gigantic glacier formerly existed, emanating from the North Polar regions, and flowing over the whole northern hemisphere.

The author said he did not adopt this view. He held that the boulder-clay was not a land deposit, but one which had been formed at the bottom of the sea; that it originally consisted of the ordinary beds of mud, sand, gravel, or boulders, such as are found generally at a sea-bottom; and that these beds were invaded by icebergs, which ploughed them up, and mingled them all together, so as to produce what is called boulder-clay. His reasons for thinking so were these—

1. True boulder-clay is not found in Switzerland, though, if its formation is due to the action of glaciers, it ought to be found there.

2. Boulder-clay is found in many places where it is not conceivable any glacier could have existed, or, at all events, have had any connection with the deposit.

3. An examination of the materials composing the boulder-clay showed that these materials had been in motion; and as it appeared that the motion was everywhere from the same direction, viz., from the west or north-west, it was impossible to explain such a uniformity of direction, extending over so large an area, without supposing that there had been a great oceanic current, which operated in producing that motion.

4. The circumstance, that almost everywhere, boulder-clay is associated with marine Pleistocene strata, and that in very many places in Scotland, Ireland, and England it contains marine fauna, is a strong proof that it has been formed at the bottom of the sea.

5. The boulder-clay shows, however, from the absence of stratification, from the broken state of the sea shells, and from the unnatural mixture in it of littoral and deep-water shells, that some agent has operated on it, causing great disturbance, and acting with immense mechanical power.

6. The accounts given by voyagers to the arctic regions, show that icebergs there disturb the sea-bottom, and produce operations very analogous to those which are inferred to have occurred in the production of the boulder-clay.

7. The character of the shells in the boulder-clay, and in other

associated beds, as well as the nature of the animals whose bones are found in it and in these beds, shows that at this epoch the climate of North-Western Europe was arctic; and the height at which shell beds of that period, as well as other marine strata, have been found, shows that Scotland must have sunk to the depth of at least 3000 feet below the present sea-level.

When the land was so submerged, icebergs came over the submerged land, and grating upon the sea-bottom, converted many of the beds into boulder-clay.

The phenomena of smoothed ridges and water sheds, the position of *blocs percés*, and the transport of boulders generally, can be better explained by floating ice than by glaciers.

8. The arctic climate of North-Western Europe was probably caused—(1.) By the Gulf-Stream flowing in some other direction than that now followed by it; (2.) By an arctic current flowing from the west or north-west; (3.) By the existence of high land in the North Atlantic, which increased the cold, produced glaciers and icebergs, and gave an easterly or south-east direction to the arctic current.

4. On the Development of the Flower of *Pinguicula vulgaris*, L., with Remarks on the Embryos of *P. vulgaris, P. grandiflora, P. lusitanica, P. caudata*,* and *Utricularia minor*. By Alexander Dickson, M.D. Edin. & Dublin., Regius Professor of Botany in the University of Glasgow.

The affinities of the order Lentibulariaceæ having hitherto been somewhat obscure, the author undertook the investigation of the floral organogeny of *P. vulgaris*, in the hope of being able to throw some light on the subject.

A plant of *P. vulgaris*, examined during the flowering season, exhibits a short axis with "radical" leaves spreading as a rosette, and terminated by an unstalked umbel of ebracteate flowers. In the axil of the last leaf is produced a bud, which, after the maturation of the fruit, supplants the now decayed main axis and forms the "autumn rosette." This autumn rosette, on the approach of winter, loses its expanded outer leaves, its central portion remaining as a firm bulb-like winter-resting bud, the outer leaves of which are developed as somewhat fleshy scales. In this bulb-like bud the rudiment of the inflorescence for the next season, along with that of the axillary bud of the last leaf, is to be seen. On the return of warm weather, towards the end of spring, the winter bud expands as the flowering rosette, while the axillary bud of the last leaf is being developed so as to form the autumn rosette as above described.

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* The observations on the embryo of this species were made after the paper had been submitted to the Society.

The author's principal results are as follows:—

1. The receptacle exhibits irregularity before there is any appearance of floral parts, its extremity being obliquely flattened downwards and posteriorly.
2. The calyx, corolla (apparently), andrœcium, and ovary appear first in their anterior part or parts.
3. The andrœcium in the young flower consists of two fertile stamens superposed to the anterior sepals, and two staminodes superposed to the lateral ones. The staminodes usually disappear at an early period.
4. The pistil originates as a semilunar elevation to the anterior side of the receptacular centre. Its extremities gradually extend themselves around that centre until the ovarian wall is completed posteriorly.
5. The placenta is strictly "free-central" being always unconnected with the ovarian wall. It has no barren apex corresponding to that in Primulaceæ; and the ovules (which are anatropal and present a single integument) appear in basipetal succession over its surface.

The author drew attention to several monstrosities, chiefly affecting the pistil. In some of these the posterior (small) lip of the stigma was bipartite, and in others the anterior (large) lip was tripartite. Combining these monstrosities, he drew the inference (which he held to be quite in harmony with the developmental facts) that the pistil of *P. vulgaris* consists of five connate carpels; its bilabiation being comparable to that of the corolla in *Utricularia minor*, where five parts are united into a structure with two *entire* lips.

The author is inclined to set aside the ordinary idea of a close affinity with Scrophulariaceæ. If the supposed correspondence in the number of carpels has no reality, the orders have actually nothing in common save bilabiation and didynamy; but these characters are found in so many different types that they are of very small value in determining the affinities of a given plant. On the other hand, he showed that Lentibulariaceæ, in having a free-central placenta and (probably) five carpels, differ little from Primulaceæ except in the superposition of the stamens to the sepals, and the exalbuminous character of the seed.

The author thought that Salvadoraceæ should be placed near Lentibulariaceæ, as had been done by Payer in his "Leçons sur les fam. nat. des plantes," and suggested that *Salvadora*, with oppositisepalous stamens and solitary exalbuminous seed, bears the same relation to Lentibulariaceæ with numerous exalbuminous seeds, as Plumbaginaceæ with oppositipetalous stamens and solitary albuminous seed, bears to Primulaceæ with numerous albuminous seeds: Salvadoraceæ with Lentibulariaceæ, on the one hand, and Plumbaginaceæ with Primulaceæ on the other, forming two parallel, nearly allied series.

The author also drew attention to the embryos of *Pinguicula vulgaris*, *P. grandiflora*, *P. lusitanica*, and *Utricularia minor*. A very brief statement by him of the differences between those of the two first had already appeared in the report of a meeting of the Dublin Microscopical Club, on 21st November 1867 (Microscopical Journal, viii. pp. 121–2); but a more detailed account was now submitted along with figures. He was able to confirm St. Hilaire's statement as to the dicotyledony of *P. lusitanica*, which, when contrasted with the monocotyledony in the two first named species of the genus, is very remarkable; and in a Mexican species, *P. caudata*, the author has also found two cotyledons. In *Utricularia minor* the embryo is somewhat globular, and at first sight appears to have a smooth undivided surface; on careful inspection, however, a remarkable conformation is to be observed of that end of the embryo which is remote from the hilum of the seed, viz., a minute *punctum vegetationis* surrounded by four very slight elevations forming the somewhat incurved sides of a square. He was not prepared to call these four elevations *cotyledons*, but considered the whole structure interesting as showing this embryo to be a little in advance of a mere "embryonal globule."

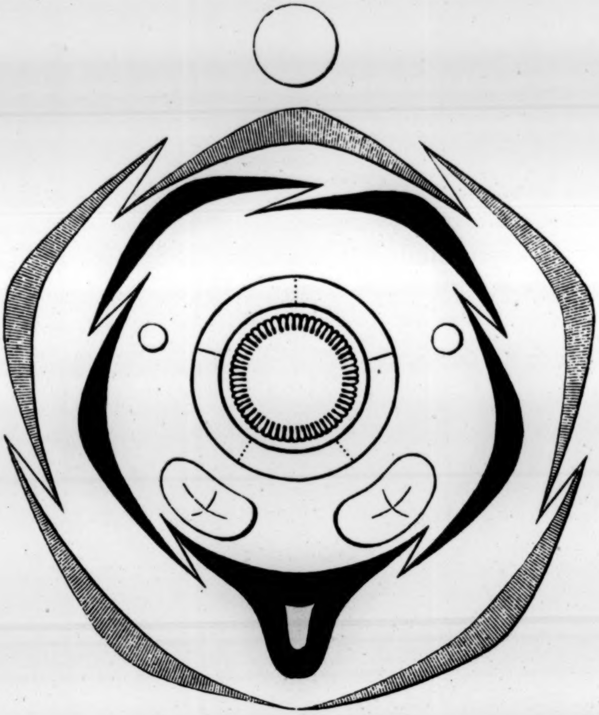

Diagram of the flower of *Pinguicula vulgaris*, L., showing the æstivation of calyx and corolla, the stamens and staminodes superposed to the anterior and lateral sepals, and the one-celled ovary with free-central placenta. The wall of the ovary is represented as divided into five parts by two plain and three dotted lines, the two plain lines representing the division of the stigma into two lips or of the capsule into two valves, the three dotted lines representing the abnormal fissures in the above mentioned monstrosities.

5. Observations on New Lichenicolous Micro-Fungi. By Dr W. Lauder Lindsay.

The author's "Observations" relate mainly to the Microscopic Anatomy of the reproductive tissues and corpuscles of about fifty Lichenicolous Parasites—apparently new species—referable partly to the true *Fungi*, and partly to the *Fungo-Lichenes*. These parasites, themselves microscopic, have accumulated in the author's Herbarium during the last twelve or fifteen years: or were examined by him while determining the species of various British and foreign Lichen-collections submitted for that purpose during the same period.

The types of the parasites referred to are—

Torula lichenicola.
Coniothecium lichenicolum.
Sphæria ventosaria.
Microthelia Cookei.
  Stereocaulicola.
  Umbilicariæ.
  Nephromii.
Microthelia rugulosaria.
  Stictaria.
  Parietinaria.
  Bæomycearia.
  atricola.
  vesicularia.

Detailed observations are included on the variations of *Torula lichenicola* and *Coniothecium lichenicolum.*

The group of parasites described (accompanied with two plates of seventy figures illustrative of their minute structure) is representative of a large and important section of obscure and little understood organisms that are midway in character between Lichens and Fungi, and which have been scarcely studied by either Lichenologists or Fungologists. The observations made upon them by the author illustrate several points of great interest in the physiology, anatomy, morphology, and classification of the lower orders of Lichens and Fungi, *e.g.*—

1. The extent to which Lichens are affected with parasitic growths.
2. The external resemblance between these parasites—whether Lichens, Fungi, or Fungo-Lichens—and the
   Spermogonia,
   Pycnidia, } of Lichens or Fungi.
   Apothecia or Perithecia,
3. The connection between parasitic growth and deformities or degenerations of the Lichen-thallus or apothecia.
4. The closeness of the alliance between Lichens and Fungi: the impossibility of drawing lines of demarcation.
5. The fallacies of supposed diagnostic characters or differential tests between Lichens and Fungi: especially the iodine-reaction-test.
6. The usefulness of establishing a group intermediate between Fungi and Lichens—of *Fungo-Lichenes.*

7. The variations of spores or sporidia in the same species.
8. The occurrence of different forms of reproductive corpuscles in the same perithecium.

The author's paper includes also descriptions of two new parasitic *Micro-Lichens*—

Lecidea Endocarpicola, and
Abrothallus Moorei :

and of one non-parasitic *Micro-Fungus*—

Peziza lichenoides.

He contributes also to a fuller knowledge of the minute anatomy of various lichenicolous parasites, whose names and specific characters have already been published, but which are nevertheless as yet little known, *e.g.*—

Sphæria Hookeri.
Spilomium Graphideorum.
Gassicurtia silacea.
Microthelia Collemaria.

6. On the Theory of the Formation of Ammonia when Nitrogen and Aqueous Vapour are passed over Magnesium. By A. R. Catton, M.A.

In a paper recently communicated to the Society by Mr Main and myself, we showed that when nitrogen and aqueous vapour are passed over magnesium ammonia is formed. We took for granted the theory of the reaction to be that the magnesium decomposes the aqueous vapour, and that the hydrogen thus produced, when in the nascent state, combines with nitrogen and forms ammonia. In a discussion which followed the reading of the paper, Mr Dittmar maintained that such was not the theory of the reaction, but that nitride of magnesium is first produced, and then decomposed by the aqueous vapour into ammonia and magnesia.

I gave what appeared to me a conclusive answer to this supposition—which I was certainly surprised to find seriously maintained—for it seemed in every point of view so entirely untenable, that I did not think it worthy of notice in our paper.

As, however, the formation of ammonia in the manner we described is a point of considerable interest, I have thought it right to embody the remarks which I then made in the note now presented to the Society, in order to remove the doubt which I find exists in the minds of some as to the theory of the reaction.

That the ammonia is not due to the action of aqueous vapour on nitride of magnesium is, I think, clearly shown by the following considerations:—

(1.) Nitride of magnesium is a very unstable compound, and is stated to decompose water with such violence that it makes the water boil. *A priori* it is a very strong objection to an explanation which assumes the formation of a body under the very conditions which decompose it. To say that nitride of magnesium could be formed in the presence of aqueous vapour, is pretty much the same thing as to say that potassium could be formed in the presence of water. It is certainly the duty of those who make a supposition so entirely at variance, as I think, with dynamical considerations, to support it by some experimental evidence.

(2.) Nitride of magnesium is only formed when magnesium is heated to a high temperature in presence of nitrogen. But ammonia is formed in small quantity in our experiments when nitrogen and aqueous vapour are passed at *low temperatures* over magnesium. In this case, it is certain that nitride of magnesium is not produced; for it would not be produced if aqueous vapour were not present, and it surely will not be pretended that the presence of aqueous vapour might induce the formation of nitride of magnesium under conditions in which it would not be formed in its absence.

It is equally certain that at low temperatures magnesium decomposes aqueous vapour with formation of hydrogen; and in the union of nascent hydrogen and nitrogen, we have a sufficient, and, as I maintain, the only explanation of the formation of ammonia.

(3.) To suppose that nitride of magnesium could be formed is equivalent to maintaining that magnesium has, in the conditions of our experiments, a greater affinity for nitrogen than for oxygen, which the instability of the nitride and the great stability of the oxide of magnesium shows is not the case. This reason alone is sufficient to negative the supposition of the formation of nitride of magnesium.

(4.) Nitrogen and aqueous vapour passed over *sodium* yielded no ammonia. The reason for this was said to be that a nitride of sodium does not exist. The real reason for the non-formation of ammonia appeared to be due to the violent action of the aqueous vapour on the sodium. If sodium amalgam were used in order to modify the action of the sodium, we believe that ammonia would be produced. It is our intention to try this experiment.

[A discussion followed the reading of this paper, in which Professor Crum Brown, Mr Dewar, and Mr Catton, took part.]

Monday, 3d *May* 1869.

DR CHRISTISON, President, in the Chair.

The following Communications were read:—

1. Influence of the Vagus upon the Vascular System. By William Rutherford, M.D., F.R.S.E., Demonstrator of Practical Physiology in the University of Edinburgh.

Abstract.

The author gave the *chief* results of 120 experiments upon frogs, rabbits, and dogs, as follows:—

1. He showed, by novel methods of experimentation, that the inferior cardiac branches of the vagi are—as the brothers Weber pointed out—inhibitory nerves of the heart, and that they cannot in any sense be regarded as motor nerves of the heart, as maintained by Schiff, Moleschott, Lister, and others. The experiments bearing on this question were performed in 1866–67.

2. Because the heart usually beats more rapidly after division of the vagi, Von Bezold and others have concluded that the vagus is continually restraining the heart's movements. The author showed that *increase of the blood pressure* is generally the cause of the quickened cardiac action after division of the vagi, a fact which had been overlooked by all previous observers. Von Bezold's theory, that the vagi continually inhibit the heart, was therefore shown to be devoid of the necessary proof.

3. It had been noticed by many observers that after division of both vagi the blood-pressure usually rises. This has always been ascribed to the quickened rate of cardiac action; but the author proved that it is usually due to the contraction of abdominal blood-vessels, chiefly those of the stomach. Division of the vagi is followed by rise in the blood pressure—in general—only when the animal is digesting its food; that is, when the gastric blood-vessels are dilated previous to the division of the nerves.

4. The vessels of the stomach appear to be dilated during digestion, chiefly by the vaso-inhibitory action of incident filaments of the vagi upon the splanchnic nerves (the vaso-motor nerves for the gastric vessels).

5. By the discovery of the above fact additional support is given to the theory that the contractile elements of the entire vascular system are presided over by two kinds of nerves—one motor, the other inhibitory. The former brings about contraction of the vascular system, the latter causes its dilatation by throwing the vaso-motor nerves into a state of rest.

The experiments bearing on the questions embraced in 2, 3, 4, and 5, were chiefly performed in 1868.

2. On Free An-atomic or Transmissible Power. By R. S. Wyld, Esq. (*Second Paper.*)

Observations on Animal Power, its Nature and Source. And on Sense-perception, as a Perception of Power.

In the first part of the paper I adduce probable, or *prima facie*, evidence in favour of the theory that the power which produces voluntary motion is not derived solely, nor even chiefly, from the decomposition of the muscular tissues, as has been generally, if not universally, held by recent investigators, but is derived primarily and principally from the decomposition of the cerebral tissues; and second, that this decomposition of the brain is effected by a direct voluntary mental effort.

My views may be briefly stated in the following propositions:—

1*st*, Free force is liberated by the dissolution and decomposition of simple and compound bodies, and especially by the decomposition of vegetable and animal organic tissues.

2*d*, An immense amount of free force is being constantly liberated by the process of decomposition going on in the body of the living animal, and it is thus that heat, one of the prime agents in the animal economy, is supplied to all parts of the body.

3*d*, Free force is also in this way, viz., by the decomposition of the substance of the brain, supplied to the muscles of voluntary motion, and it is the agent which causes their contractions, for the purposes of animal movement.

4*th*, This decomposition is effected by a direct mental effort, which we are conscious of exerting during voluntary muscular action.

5*th*, Though there is a notable difference between the tension of brain force and what is called galvanic force, as is marked by its ascertained inferior velocity—about 95 feet in the second—and by its having a feebler and more easily interrupted current, yet brain or nervous force seems substantially the same in its nature, source, and action, as galvanic force.

The grounds for holding that the free force which produces muscular action is derived, at least chiefly, from the brain, and not from the muscles, whose main function is to be the mechanical instruments of motion, are the following:—

1*st ground.* The brain is the centre of the nervous system. It is now, also, by the experiments of Helmholtz, Harles, Fick, Schelske, and others, ascertained to be the sole seat of sensation. Being thus the direct and only organ of the mind, it is natural, if not necessary, to conclude it to be the immediate source of animal power during voluntary muscular movement.

2*d ground.* We have a *direct experience* that the *amount of physical power obtained is*, cæteris paribus, *in constant proportion to the amount of the mental effort which we are conscious of exerting in producing this physical power.*

3*d ground.* The brain gets, according to reliable computation, probably five times the average supply of blood which is furnished to the other parts of the body, weight for weight. This circumstance requires to be accounted for, and physiological principles mark it as a proof that the brain is an organ discharging very heavy and important work, by the decomposition and reconstruction of its substance, and by the consequent liberation of free transmissible force.

4th ground. The circumstance that the complex albuminous and oleaginous constitution of the cerebral substance yields readily to decomposition, and that it is the part whose chemical combinations are the first to break up after death, serves further to strengthen the views here set forth.

The subject is, doubtless, one very difficult to investigate; for even if, in the face of much contradictory evidence, we accept the opinion that the amount of *Urea* and other nitrogenous products discharged from the body affords a correct measure of the amount of animal work performed in a given time, yet from the circumstance that both the brain and the muscles are chiefly nitrogenous in their constitution, it must ever remain difficult, if not impossible, by any mere examination of the nitrogenous excretions, to ascertain whether they are derived from the one organ or from the other, and therefore, the most ingenious and careful investigations will be required before we are entitled to dispossess the brain of what appears, on pretty strong grounds, to be one of its most important functions, viz., that of being the organ to the mind for the production of animal motion and power.

On Perception.

The second part of this paper has reference to the subject of sense-perception, or the impressions which the mind obtains by reason of its connection with the physical world.

The writer directs attention to the fact that an examination of the laws of momentum, and of the transmission of the rapid concussions and vibrations which pass through the atmospheric and ethereal media, makes it apparent that *free force* or power is transmitted from molecule to molecule of these media, and that, philosophically speaking, it is this *free force* which thus enters the brain through the appropriate nerves, and which impresses the mind with the sensations of light and sound.

The difficulty which has hitherto been felt by philosophers, not only of the various continental schools, but also of our Scottish school of philosophy, has ever been—how matter or physical substance could act on mind? This difficulty prompted Malebranche to promulgate the theory of our perceiving all things in God. It also prompted Leibnitz to maintain that there was no operative connection between the mind and external physical nature, but merely a pre-established harmony; and much the same difficulty led Berkeley to deny the existence of an external world, and to declare that our perceptions were not real, but only apparent, being mere ideas evoked in the mind by Deity.

Reid and Stewart also represented perception in the light of an inexplicable miracle, on which the study of the physical laws not only threw no light, but rather served to mislead and pervert the inquirer. The Deity they held to be the only efficient cause in perception.

Mr Wyld holds that the difficulty thus experienced by philosophers disappears the moment we carefully examine the physical phenomena. Thus in the sensations of light and sound, it is not matter or substance which affects us, but it is the force or power transmitted by the respective *media*, which affects the mind. Force or power Mr Wyld defines to be the action of an unseen immaterial agent, as proved in his former paper on "Free Transmissible Power." And wherever *movement* is observed to exist, we have evidence of the existence of *force* as its cause.

When we explore, says Mr Wyld, the links of cause and effect in the physical world, and also when we contemplate the operations of the mind, we are made aware that the seen and the unseen, the physical and the mental, rest alike on the spiritual foundation of power. Power is the immaterial or spiritual element in nature—that which produces and governs every physical phenomena; it is the copula uniting cause and effect. It is also the attribute of the active principle within us, by which we feel, and think, and move, and exercise control over external nature.

Reduced, then, to a philosophical form, we stand in this position: It is the power of the Supreme Being which constitutes the energies and forces of nature. These forces act on the mind, and the mind, as a real agent, acts on them. Our intercourse with nature thus strictly implies a connection of mind with mind,—the connection of the Great Mind with his creatures; not, however, as maintained by Malebranche, Berkeley, Leibnitz, or Reid, by miraculous interposition or action, but, on the contrary, expressly by and through the operation of the natural laws we have endeavoured to explain in the previous paper—Deity being the sustainer of these laws and of the active energies of nature.

We know that the mind of man deals with and directs free power or force, when it sends it to the muscles for the purposes of voluntary motion ; and we are therefore justified by parity of reason in holding that, when free force comes in upon the mind from the outer world, through the vibratory movements above referred to, the mind will be susceptible to its influence. This is not only a consistent, but a necessary conclusion.

It is, be it observed, not substance, but power, which the vibrating molecules bring to the mind, and which the mind receives. We may hold also that the force or power thus received or appropriated by the mind, and the physical movements which accompany it, take end in the brain, being there neutralised by the control which we know the mind to exert over physical power.

It is common, we admit, for physicists to explain the perception of light and sound as due to the vibratory *movements* of the physical molecules which impinge on the retina and auditory nerve. But in doing so they give us merely the outer manifestation, and neglect the unseen essence and efficacy. For it is the force which causes the movement, and not the movement which causes the force. It is force which causes the cannon ball to fly with its destructive violence. Take away the force, and the iron lies harmless on the ground.

Without the iron, indeed, or other atomic body, we could neither obtain nor use physical force for physical purposes, and for these reasons—first, though we can take force from one body and pass it to another, we can never obtain it freed from its physical connection. The second reason that physical substance is necessary for physical purposes is this—Though the iron is passive, and the sport of its Master—Force, and though it is force that carries it through the air, still the iron evidently performs an important part in physical dynamics. It is because iron and other atomic bodies are impenetrable by each other, that when the cannon ball meets the iron target, one or other of them must yield. The question is not, which of them is the hardest—for a piece of tallow, we know, may be fired through a deal board—the question is—whether the cohesive power of the target or the onward force of the ball is greater. If the latter preponderates, then the force necessarily carries the ball with it through the iron plate, with violent disruption of its parts.

On the same principle, it is not the movement of the molecules which, hitting the retina and auditory nerve, affects the mind with the sensations of light and sound, it is the force which they carry which accomplishes this.

Though force is the operative principle in all physical and mental action, yet mark the result were force not regulated, and bound up in connection with physical bodies. Were force freed from this connection, it would attain immediate equilibrium, and the physical universe would instantly cease to exist—action and reaction, momentum and inertia, resistance and localised force being at an end, physical law and the physical world would be at end with them—for the physical world consists but of the antagonism of contending forces.

Mr Wyld concluded by referring to the distinctive nature of our perception of the primary or solid resisting properties of physical objects, and of our other perceptions. In our sensations of light and sound, taste, smell, and touch, the mind is passive. But our perception of the primary properties of external nature depends entirely on another principle, namely, on our consciousness that the mind possesses, and exerts a command over active physical power, or the power of animal motion. When we are conscious of possessing this power, and perceive that the Will which exerts and directs it, is thwarted by our coming into visible contact with outer objects, we discover at once that these objects possess resisting power, seeing that they counteract at once our power, and our Will, and our motion.

This distinction between passive sensations and the exercise of our active mental and animal powers has not been sufficiently urged in refutation of Berkeley's Idealism. The vast majority of realists in philosophy succumb under the apparent force of the absurd argument, that all our perceptions are resolvable into mental sensations, and therefore that our belief of an outer world hangs on faith alone. Mr Wyld maintains, on the contrary, that according to the principles of his theory we have a ready and complete confutation of Berkeleyism. For the mind not only possesses a command of physical power, but it is *conscious* that it possesses it, and that it exerts it, and that its exertions are resisted by external objects; and thus, through a direct consciousness of mental power, we have an indirect, but indefeasible proof and perception of the resistance of external objects, and of the external world.

3. On the Affinities and Classification of the Nemerteans. By W. C. M'Intosh, M.D., &c.

The immediate allies of the Nemerteans are evidently the Planarians, and Ehrenberg's class *Turbellaria*, as now amended, is therefore a very natural one. There is, however, a considerable divergence between the two groups; and since it is only through the Planarians that the Nemerteans can in any way be linked on to the Trematoda, it is found that there is little structural resemblance between the two last-mentioned types. The various parts of the organism in the Trematodes and Planarians (through which the connection of the Nemerteans with the former may be supposed to occur) were contrasted, and their homologies explained. The structural relations of the Planarians and Nemerteans were then considered; and, thirdly, the connections of the latter with the higher Annelids were alluded to.

In regard to classification, the arrangements of Linnæus, Ehrenberg, Œrsted, De Quatrefages, Max Schultze, Schmarda, Keferstein, and others were examined, and the reasons why they could not now be adopted, at least without essential modifications, explained. The following classification is considered less liable to alterations in principle, since it is founded on an anatomical basis.

Order *Nemertinea.*—Worms, with more or less elongated, soft, ciliated bodies; nervous system composed of two conspicuous ganglia connected by a double commissure, and two main lateral cords; digestive system, in the form of a ciliated canal, with two apertures; circulatory system, consisting of a series of closed contractile vessels. The proboscis forms the typical organ of the order, and is surrounded by a special muscular sheath, within which it glides in a corpusculated fluid; in front it passes between the commissures of the ganglia, while the digestive tract is placed inferiorly. Sexes separate in the majority; oviparous or ovoviviparous.

The Order may most naturally be separated into two great *Sub-Orders*, distinguished from each other by the presence or absence of stylets in the proboscis, the former being called after Max Schultze, (but with amended characters), *Enopla*, and the latter *Anopla.*

The Sub-Order *Enopla* is characterised further by the rounded and somewhat double nature of the nerve-ganglion on each side, and by the fact that the lateral nerve-cords are placed within the proper muscular walls of the body. The mouth, moreover, opens on the ventral surface of the snout in front of the commissures of the ganglia. The blood-vessels are more differentiated than in the *Anopla.* The young, so far as known, do not undergo any noteworthy metamorphosis.

In the *Enopla* there exists one great group, and a subordinate one, which, however, retains so many of the characters of the former, that it has not been considered advisable to separate it into a distinct Family, but both have been placed under the Family *Ommatopleidæ.* The animals forming this Family have two muscular layers in the body-wall, an external circular and an internal longitudinal; the proboscis is composed of three divisions, anterior, middle, and posterior,—the former having in the typical forms seven coats, viz., external elastic, external longitudinal (muscular), reticulated or beaded layer, inner longitudinal, circular, basement layer, glandular layer. The middle region bears the stylets, and the posterior forms a long sac, with two muscular coats—external circular and internal longitudinal. There are three great longitudinal vascular trunks, two lateral and one median. The cephalic pits and glands are accompanied by long tubes or ducts. The subdivision of the Family referred to may be made by separating those (A) with comparatively short and thick bodies, and proportionally large proboscides; and (B) those having more or less elongated bodies, and proportionally short proboscides.

The Sub-Order *Anopla*, again, is further distinguished by having the nerve-cords placed between the muscular layers of the body-wall. The mouth opens on the ventral surface behind the commissures of the ganglia. The blood-vessels are somewhat less differentiated than in the Enopla. The young in the most conspicuous Families undergo a remarkable metamorphosis.

In this Sub-Order there are several Families, the most conspicuous and typical of which is that of the Borlasidæ, characterised by the more or less elongated shape of the ganglia, the arrangement having with the commissure the form of a horse-shoe. The muscular covering of the body is composed of three layers—external longitudinal, circular, and internal longitudinal. The proboscis is furnished with five coats, viz., external elastic, external longitudinal and accessory bands, circular, basement, and glandular layers. The circulatory system consists of three great longitudinal trunks, two lateral and a dorsal, which frequently anastomose by transverse branches, form a *rete mirabile* in the œsophageal region, and unite in lacunæ behind the ganglia. Head, with deep lateral fissures in connection with the cephalic gland, which is rounded, and not furnished with long tubes or ducts.

A curious specimen from Herm forms the type of a group that would require to be raised to the rank of a Sub-Family, but as only one specimen has yet been found, it is thought advisable to postpone this at present, and distinguish it only generically. In this animal the proboscis is extremely slender in proportion to the bulk of the body, and in its minute structure differs from the type of the Borlasidæ in having no accessory bands cut off from the longitudinal layer. Externally the organ has an elastic investing layer, then a longitudinal, within which are a thin circular and a glandular coat. The reddish colour of the muscles of this species, and the tinted circulation, are likewise quite characteristic.

A more distinct Sub-Family of the Borlasidæ than the foregoing, perhaps, is that of the Borlasian without lateral slits. The anatomy of the body-wall agrees with Lineus, but there are no cephalic fissures. The structure of the proboscis is also characteristic, for there is externally no distinct investing layer, the outer coat consisting of spiral and interwoven muscular fibres, the middle of longitudinal, and the internal of the usual glandular coat.

The *Meckelidæ* constitute a very distinct Family of this Sub-Order. The general structure of their nervous system agrees with Borlasia, but the lateral nerve-cords are placed between the circular (external) and the longitudinal (internal), these being, moreover, the only two muscular coats of the body. There are no lateral fissures. The circulatory system consists of two great lateral trunks. The proboscis has externally a double elastic layer, a thick longitudinal coat, and internally a glandular layer.

The Family of the *Cephalothricidæ* deviates still more from the typical group. The arrangement of the ganglia differs, and the commissures are separated by a considerable antero-posterior interval. The lateral nerve-cords lie between the longitudinal layer and an isolated inner band of fibres having the same direction. The proboscis is supplied with acicular papillæ, and seems to have an external circular and an internal longitudinal coat. Snout devoid of fissures. Circulatory system composed of two great longitudinal trunks, which communicate anteriorly and posteriorly. Oviparous: the young undergoing no true metamorphosis, although they possess eyes, whereas the adults are generally eyeless.

4. On the Alkaloids contained in the Wood of the Bebeeru or Greenheart Tree (*Nectandra Rodiœi*, Schomb.) By Douglas Maclagan, M.D., F.R.S.E., Professor of Medical Jurisprudence in the University of Edinburgh, and Arthur Gamgee, M.D., F.R.S.E.

When the wood of the bebeeru tree is subjected to a process similar to that recommended in the British Pharmacopœia for the separation of bebeerine from the bark, a mixture of several alkaloids is obtained.

In this memoir the authors specially describe the properties of one of these alkaloids, to which they have assigned the name Nectandria and the formula $C_{20}H_{23}NO_4$. (Bebeerine, according to V. Planta, has the formula $C_{18}H_{21}NO_3$). Nectandria is obtained by treating the mixed alkaloids obtained from the wood with chloroform, in which it is abundantly soluble.

From the chloroform solution it is obtained in the form of a fawn-coloured substance, which is quite amorphous. It differs from Bebeerine in being almost absolutely insoluble in ether, and in fusing when placed in boiling water. By treating the solution of the hydrochlorate of this base with animal charcoal, and then precipitating the solution with ammonia, the authors succeeded in obtaining the base of an almost pure white colour. When dissolved in acid this powder, however, yielded yellow solutions.

When Nectandria is treated with sulphuric acid and binoxide of manganese a magnificent green colour is developed, which slowly changes to a violet, which cannot be distinguished from that produced under similar circumstances with strychnia. This reaction, which is of exceeding delicacy, is not possessed by bebeerine. Nectandria has no effect in rotating the ray of polarised light.

After separating nectandria by means of chloroform, the authors treated the mixed bases with boiling water, which readily acquired a rich yellow colour, and an intensely alkaline reaction. On cooling, the water deposited a yellow precipitate, which was found to consist of microscopic nodules. The substance dissolved by the water is a very powerful base; its compound with platinum is noular, and differs from the double salt of platinum and nectandria in being fusible in hot water. This new base is insoluble in chloroform, decidedly soluble in water (one part is soluble in 56·8 parts of cold water) and insoluble in ether.

When treated with binoxide of manganese and sulphuric acid it gives exactly the same reaction as nectandria.

The taste of this base is peculiar, being both bitter and astringent.

The platinum compound of the new base was analysed, and found to contain (1) 20·1 per cent. of platinum and (2) 20·57 per cent of platinum.

After separating the two bases above referred to a brown residue remains, which is insoluble in chloroform, ether, and water, but soluble in alcohol. The alcoholic solution possesses an alkaline reaction. This substance forms compounds with acids, and yields an amorphous compound with platinum.

The authors propose to examine in the sequel the physiological and therapeutical properties of the true bases treated of in this paper, as well as to investigate in a special manner the chemical relations which exist between them.

Monday, 17*th May* 1869.

Professor KELLAND, Vice-President, in the Chair.

The following Communications were read:—

1. On the Basin of the Firth of Forth, and some of its Geological Phenomena. By David Milne-Home, Esq.

I. An account was given of the dimensions of the estuary, in respect of length, width, and depth; and also of the general direction of the axis of the estuary.

II. It was next shown that the formation of the estuary was probably due to the great geological fractures and dislocations which had taken place in this part of Scotland, inasmuch as the direction of these was parallel, or nearly so, to the axis of the estuary, and as the downcasts in the adjoining counties on the north and the south were all towards the estuary, thus producing a trough or valley, deep enough to be entered and filled by the sea.

III. The author, before describing the newer deposits filling the basin of the Frith of Forth and covering its adjoining shores, stated that the materials of these deposits were most probably derived from the upcast strata which, along the slips and fractures, had formed high exposed cliffs, and which yielded to the influence of the sea, if the sea covered them, or atmospheric changes, if they were above the sea-level.

1. There were no data for determining *when* these dislocations took place. There was clear evidence, however, that in the Western Highlands there had been outbursts of trap at a period later than the chalk; and Mr Cumming thought, that in the Isle of Man part of the boulder-clay had been formed after great dislocations there.

2. An account was then given of the various kinds of deposits, chiefly by means of reports obtained of borings, which showed the layers of clay, sand, and gravel passed through, with the thickness of each.

3. It was observed that clay generally occupied the lowest levels, sand and gravel the higher levels, a reason for which was assigned. The bed called "*sleech*" or "*sludge*" was described, as also the "*brown*" or "*carse clay*;" and the question was raised, whether the *peat* beds, which also appeared among the deposits, were *in situ*, or whether they were formed of drifted materials. The sub-marine forest on the Fife coast was noticed.

Some account was given of the *sea-shells* found in the districts, it being explained that they occurred sometimes in positions where they were entire, and also in other places where they were broken. It was supposed that in the former case the shells were now where they lived and died; in the latter case, where they had been thrown up on beaches.

An enumeration of the *Whale skeletons* discovered was next given.

4. Some details were entered into regarding beds of *sand* and *gravel*, and the pebbles found in both, particularly the fragments of coal, as indicating the quarter from which the transporting agent had moved. The subject of *kaims* was adverted to, which the author ascribed to the action of sea-tides and currents.

Some ancient *deltas* along the foot of the Ochil Hills were noticed and shown in a map.

5. *Boulders* of a large size were pointed out, with a notice of striæ on several, and of the direction of the striæ.

These boulders were described as belonging to two distinct classes, the one being rounded, the other angular, and each being in such different circumstances as to suggest a different mode of transport for each class. All the boulders in this district, however, appeared, from the nature of the stones composing them, to have come from the west or north-west, in this respect agreeing with the direction of the striæ on the boulders and rocks, and with the direction, in most instances, of the longer axis of the boulders.

6. The next topic adverted to was the lines of rocky cliffs and caves, at a height of from 15 to 30 feet above the present sea-level, which proved that the sea had stood that much higher formerly.

The author then proceeded to show that almost all the hills in the district presented smoothed or bared fronts to the west, and that many of them were worn down and grooved in such a way as to show that some powerful and heavy agent had passed over them.

These markings were particularly visible in the gorge of the estuary at Stirling, and up to a level of above 350 feet.

7. Attention was next called to the boulder-clay of the district, whose irregularity, both of distribution and of thickness, was pointed out.

The fact of marine beds found above, below, and in the heart of the boulder-clay was noticed, as also the force with which it appeared to have been pushed by some agent or agents in an easterly direction.

The colour of the boulder-clay, varying as it does in different districts, seemed to be owing to the colour of the rocks situated in each case to the westward, and it was observed that beds of stratified or laminated clay sometimes showed different colours, concurrently with the boulder-clay.

The author next adverted to the two theories proposed to explain the origin of the boulder clay, the one being that it was mud formed by a glacier grinding the rocks, over which the glacier flowed, and the other that it was formed by icebergs ploughing through and mixing up a previously existing sea-bottom composed of mud, sand, clay, gravel, and boulders. He stated that he adopted the second view, and specified some of the difficulties of the question, all of which he thought could be more completely solved by the iceberg than by the glacier hypothesis.

8. The author then adverted to the subject of ancient sea-margins, four or five of which he specified, mentioning the names of places where they had been observed by himself or others.

The lowest of these sea-margins he had drawn on a map, which he exhibited, and the height of this margin he stated was, at the head of the old estuary (west of Stirling), about 30 feet above the same old sea-margin at Dunbar. This rise he attributed to tidal action exclusively, pointing out that even now, when the estuary is so much shallower, the sea-level at Alloa is 6½ feet higher than at Dunbar, and that there are other estuaries, in this country and others, where now the sea-level is at their head more than 30 feet above the level at their mouth.

9. The author said that the change in the relative levels of sea and land, which these ancient sea-margins indicated, might have been brought about either by the land rising or by the sea sinking;

and he was inclined to think the last process, however it was to be accounted for, seemed more in accordance with the facts, and, in particular, with the horizontality of these sea-margins, which, being over an extensive area, could scarcely have resulted from volcanic elevation of the land.

10. The author adverted to an opinion by Mr Geikie, and countenanced by Sir Charles Lyell, that the last change in the relative levels of sea and land took place in the Firth of Forth since the time of the Romans, which opinion he thought was disproved by the number of military works of the Romans in the district about Stirling, which could never have been made had the sea then stood 20 or 30 feet higher than at present.

At the same time, he thought there was evidence to show that human beings occupied this part of Scotland when the sea had stood at that higher level, and that as there were also grounds for believing that the climate of Scotland had then an arctic character, the subterranean dwellings, called "weems" and "Picts' houses," found in many parts of Scotland, might very probably be referred to the epoch which preceded the change of sea-level.

2. On Comets. By Professor Tait.

(*Abstract.*)

The principal object of the paper is to investigate how far the singular phenomena exhibited by the tails of comets, and by the envelopes of their nuclei, the shrinking of their nuclei as they approach the sun, and *vice versâ,* as well as the diminution of period presented by some of them, can be explained on the probable supposition that a comet is a mere cloud of small masses, such as stones and fragments of meteoric iron, shining by reflected light alone, except where these masses impinge on one another, or on other matter circulating round the sun, and thus produce luminous gases, along with considerable modifications of their relative motion. Thus the gaseous spectrum of the nucleus is assigned to the same impacts which throw out from the ranks those masses which form the tail.

Some of the most wonderful of the singular phenomena presented by comets, such as the almost *sudden* development of tails of many millions of miles in length, the occurrence of comets with many tails, and the observed fact that there is no definite relation of direction between a comet's tail and its solar radius-vector, are here looked upon as due to the differences of motion of these discrete fragments relatively to the earth, in a manner somewhat analagous to the appearances presented by a distant flock of sea-birds flying in nearly one plane, and only becoming visible (as a long streak) when the plane of the flock passes approximately through the spectator's eye. The so-called envelopes are compared with the curious phenomena presented by tobacco-smoke (which seems, however, to be emitted in a form apparently resembling thin *continuous* films of small particles of carbon), and the so-called "gaseous jets," which appear to be projected from the nucleus and to be *repelled* from the sun, are not difficult of explanation from the general point of view here taken.

The investigations are mainly conducted by quaternions, and show how a group of discrete masses, so small that their mutual perturbations are not of great moment, except in the case of actual impact, gradually changes its form as it revolves about the sun; independently of any hypothesis as to the cause (planetary attraction or otherwise) by which it was first introduced into the solar system.

The author had some hesitation in bringing forward this paper, as he did not know how far Schiaparelli, whose recent discoveries have been so very novel and remarkable, had carried his investigations. The ideas here brought forward had occurred to him immediately on his being made aware (more than two years ago) of the identity of the orbits of the August meteorites and of Comet II., 1862: but they seemed so obviously to follow from that identity that it was only on reading Dr Tyndall's recent speculations, which seem to have been well received; and on being informed by Professor Newton (of Yale Coll. U.S.A.) that the questions of tails, envelopes, and "gaseous jets" had been treated by Schiaparelli as proving the existence of a repulsive force (such as seems to have been admitted by Bessel and others, who observed Halley's comet on the occasion of its last return), that he ventured to produce to the Society an explanation so apparently simple, yet so inconsistent with what appears to be held by the majority of astronomers. The mathematical part of the necessary investigations could hardly have been made so simple and yet comprehensive as it now is had quaternions not been employed.

3. Hegel and the Metaphysics of the Fluxional Calculus. By W. R. Smith, Esq. Communicated by Professor Tait.

(*Abstract.*)

The object of this paper is to consider the mathematical value of Hegel's discussion of the fluxional calculus. This discussion, as contained in several notes in the "Logik," professes to evolve the true principle of the calculus in a form free from the inconsistencies of the usual processes, and to show how this principle may be rendered useful in the solution of problems. To clear the way for this new theory, Hegel engages in a sharp polemic against the expositions of several parts of the calculus given by Newton and others.

As these strictures on Newton have, at least in part, been received with great satisfaction by metaphysicians, the paper seeks first to show that the notion on which Newton based his doctrine of fluxions, viz., the generation of magnitudes by continuous motion at definite (but not necessarily constant) velocity, really has a place in nature. If we remember that Newton always views fluxions as a method belonging to physics (kinematics), we shall find the whole developments of his calculus to be thoroughly consistent and simple. It is shown, however, that Hegel, while he professes to approve of Newton's fundamental notions, has so completely misunderstood the whole method as to propose to eliminate as inessential the conceptions of movement and velocity, and then to blame Newton for attempting to use the calculus to do work for which it is fitted just because it is based on the notion of continuous movement. Not only does it appear that Hegel has failed to appreciate Newton's general principle, he seems also to have quite failed to understand what mathematicians mean by a limit. His strictures on the doctrine of limits are in no sense directed against any tenet of mathematicians, but only against certain absurdities which he supposes mathematicians to hold. This especially appears in his inability to understand what is meant by the evaluation of a

function which takes the form $\frac{0}{0}$; but the most interesting point in the details of this part of Hegel's work is his criticism of Princip. ii. lem. 2. Hegel accuses Newton of an error in elementary algebra, but in reality Newton's work is strictly accurate, and Hegel has merely failed to see the point of the problem. Hegel's own views of the calculus were got from Lagrange, whose treatise, with all its analytical skill, is yet a fruit of the very *Aufklärung* which in other matters Hegel especially opposes. Mistaking the abstract formalism of Lagrange's intrinsically erroneous and now quite abandoned method for superior generality, Hegel still thinks it possible to reject certain incumbrances that cling to Lagrange, and which are in fact inevitable concessions to the *physical* view of the calculus, without which the method could have no value.

Absolutely identifying analytical with algebraical method, and thus freed from all the difficulties about continuity which occur in the ordinary processes of algebra, Hegel, of course, cannot appreciate these parts of Lagrange's work. He gives a simplified theory, and applies it, among other things, to the problem of drawing tangents. Hegel professes to deduce the correct rule, but he does so only by adopting an utterly false definition of a tangent, which, in fact, gives an infinite number of tangents at every point of a curve. In short, in this and other cases, Hegel makes errors of a mathematical character sufficient to show that his knowledge of the calculus was absolutely worthless.

4. On the Connection between Chemical Constitution and Physiological Action:—On the Physiological Action of the Salts of Ammonia, of Tri-methylamine, and of Tetra-methyl-ammonium; of the Salts of Tropia, and of the Ammonium Bases derived from it; and of Tropic, Atropic, and Isatropic Acids and their Salts. With further details on the Physiological Action of the Salts of Methyl-Strychnium and of Ethyl-Strychnium. By Professor A. Crum Brown and Dr Thomas R. Fraser.

(*Abstract.*)

In papers which the authors have already communicated to this Society, they have shown that there exists a very marked difference

between the action of bases containing nitrogen as a triad and those in which that element is pentad. This result was obtained from an examination of the physiological action of substances having an unknown and complex constitution. It appeared to be necessary to institute a series of experiments with bodies having a simpler and fully known constitution. For this purpose, the salts of ammonia, tri-methylamine, and tetra-methyl-ammonium were selected. A comparison of the structural formulæ of the hydrochlorates of these bases shows that tri-methylamine stands in the same relation to the salts of tetra-methyl-ammonium as strychnia to the salts of methyl-strychnium.

The iodide of tetra-methyl-ammonium was prepared by mixing iodide of methyl with an excess of ammonia dissolved in alcohol, and recrystallising the crystalline precipitate from hot water. From the iodide the hydrate was obtained by the action of oxide of silver; and by distilling the hydrate and conducting the vapours into hydrochloric acid, the hydrochlorate of tri-methylamine was obtained.

In their general physiological effects these substances very closely resemble each other. The most obvious symptoms which they produce are paralysis and slight muscular spasm; and when these symptoms were carefully analysed, by restricting the poisonous action to certain defined regions in frogs, it was ascertained that they are caused mainly by a direct action on the cerebro-spinal nervous system and on striated muscles. When large doses are given, the functional activity of these structures is first impaired and then destroyed; but during the stage of impairment, a slight degree of spasmodic action is produced, which may probably be referred, in frogs, to the stage of irritation which precedes the final action of the majority of muscular poisons, and, in mammals, to this action, aided by changes in the vascular condition of the central nerve organs, due to an influence on non-striated muscles.

The physiological effects of chloride of ammonium and of hydrochlorate of tri-methylamine were found to be extremely similar, both in degree and in kind, and to differ, in several important respects, from those of iodide of tetra-methyl-ammonium. The two former substances are comparatively feeble in their action; the latter is a poison of considerable energy. Chloride of ammonium and hydrochlorate of tri-methylamine develop their full effects sluggishly; but the different structures which they influence have their activity destroyed nearly simultaneously, so that it is a matter of considerable difficulty to ascertain whether the muscles are paralysed before the motor nerves, or the latter before the sensory, or whether the nerve-trunks or periphery are first affected. Iodide of tetra-methyl-ammonium, however, very rapidly destroys the conductivity of the motor nerves by an action on their peripheral terminations, and an interval of several hours may elapse before its other effects are fully developed.

While the change of physiological action, produced by the addition of iodide of methyl to tri-methylamine, differs in some respects from that produced by the performance of the same operation upon strychnia, the observations now communicated tend to confirm the conclusion drawn from the previous experiments of the authors, that paralysis of the peripheral terminations of motor nerves is a characteristic effect of the salts of the ammonium bases.

The decomposition of atropia by means of acids and bases has lately been completely studied by Kraut* and by Lossen.† It appeared of interest to examine the physiological actions of the products of this decomposition, and to compare them with that of atropia. The reaction may be expressed by the equation—

$$\underset{\text{Atropia.}}{C_{17}H_{23}NO_3} + \underset{\text{Water.}}{H_2O} = \underset{\text{Tropic acid.}}{C_9H_{10}O_3} + \underset{\text{Tropia.}}{C_8H_{15}NO}$$

The tropic acid is further changed by loss of water into two isomeric acids, atropic and isatropic ($C_9H_8O_2$), the former being produced most abundantly in the presence of alkalies, and the latter in the presence of acids. These substances were prepared by the methods given by Kraut and by Lossen; and, on account of the readiness with which the acids pass by oxidisation into formic and *a* toluic acids, the action of the latter acid, prepared by the method which one of the authors communicated to this Society some years ago,‡ was also examined.

Each of these substances has been examined by the authors, and it was found that none of them possesses the well-known dilating action of atropia on the pupil. The experiments were made with the hydrochlorate of tropia and with soda salts of each of the acids. Although, however, tropia differs so strikingly from atropia in being quite unable to influence the pupil, it resembles it in some of its other physiological effects. Like atropia, it is a powerful paralysing agent, and it produces paralysis in very much the same way as atropia does. In virtue of this action, tropia is an active poison.

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* Annalen der Chem. u. Pharm., cxxviii. 280; cxxxiii. 87; cxlviii. 238.

† Ibid. cxxxi. 43; cxxxviii. 230.

‡ Proceed. Roy. Soc. Edin. v. pp. 409, 455.

Apart from the immediate object of these researches, some interest is attached to this portion of the investigation on account of its bearing on practical therapeutics. It has been shown by Professor Garrod, that when small quantities of caustic potash or soda are added to solutions of hyoscyamus, stramonium, belladonna, or atropia, the activity of these substances appears to be destroyed.* More recently, Dr John Harley, of London, has pointed out that the same effect is produced by caustic lime and by ammonia.† This conclusion was arrived at, principally, by observing that the pupil was not affected by preparations to which they had previously added one or other of these alkalies. The decomposition effected by potash, soda, lime, and ammonia, is the same as that which the authors have described; and by an examination of the separate products of this decomposition they are enabled to confirm the observation of Drs Garrod and Harley, and to add to it the additional fact that the products of this decomposition are not altogether inert.

The last portion of this paper, to which the authors think it advisable to draw attention, is that in which they describe some experiments with the salts of methyl- and of ethyl-strychnium, which were performed subsequently to their first communication. These additional experiments were made with the view to establish beyond the possibility of doubt, the truth of their statement, that these substances act as simple paralysers of motor nerves. In a paper recently communicated to the French Academy of Sciences, two able observers, Messrs Jolyet and Cahours, have confirmed the result that these substances possess an action analogous to that of wourali (curara); but they have, besides, observed symptoms which induce them to believe that this analogy is not a very perfect one, as the methyl- and ethyl-derivatives of strychnia seem to retain a certain degree of the characteristic convulsant action of strychnia.* They found their opinion on the appearance of tetanic spasms in the limb of a frog, whose vessels had been ligatured before the poisoning, and on the production of coexisting paralysis and convulsions in mammals poisoned by these substances. Both of these effects are obviously explainable by the presence of a minute trace of strychnia. In the case of the frog with the vessels of one limb tied, the methyl- or ethyl-strychnium salt paralysed all the motor nerves to which it had access; but as strychnia was also administered, *by accident*, the excitability of the spinal cord was exaggerated, and tetanic spasms therefore occurred in the non-poisoned limb—its motor and sensory nerves being protected from the paralysing action of the methyl- or ethyl-derivative. The appearance of strychnic effects in mammals may likewise be explained by the presence of strychnia. One of the authors has shown, in a paper communicated to this Society, that when a sufficient dose of a substance that paralyses the terminations of motor nerves is administered to a frog along with a certain proportion of one that stimulates the spinal cord, the symptoms are those of paralysis alone; but when this combination is administered, in the same relative proportions, to a mammal, the symptoms are those of paralysis coexisting with convulsions.† This result is sufficient to account for the different symptoms observed by Messrs Jolyet and Cahours on frogs and on mammals, on the supposition that the methyl- and ethyl-strychnium salts they employed contained strychnia.

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* Medico-Chirurgical Transactions, vol. xli. 1858, p. 53.

† The Old Vegetable Neurotics, 1869, p. 211.

The authors have made a number of experiments which support this supposition. Several specimens of these salts, prepared by them, were found to produce such complicated effects as the French physiologists describe; but by carefully treating them a second time with iodide of methyl or of ethyl they succeeded in removing the convulsant action. They have also treated a specimen of iodide of ethyl-strychnium that produced strychnic effects, with iodide of methyl, and thus obtained a substance whose action was a purely

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* Comptes Rendus, Nov. 2, 1868, p. 904.

† Proceed. Roy. Soc. Edin. vol. vi. p. 434.

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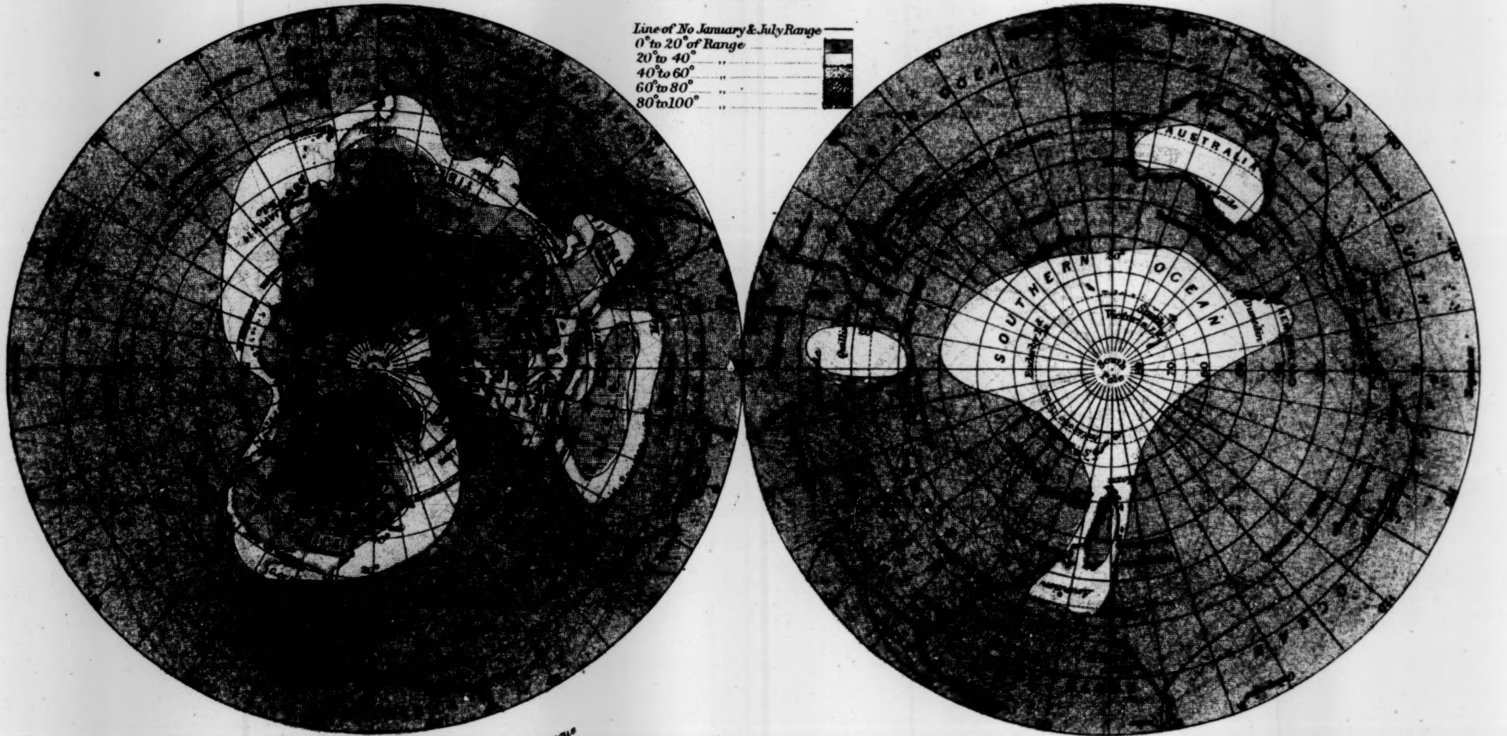
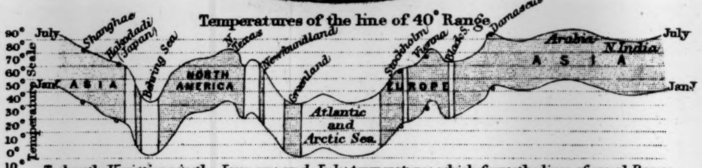
ANNUAL RANGE OF TEMPERATURE

OVER THE GLOBE

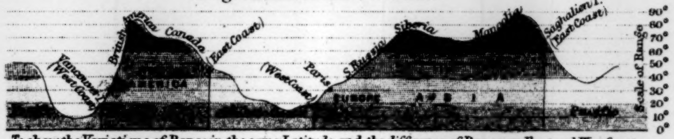


Temperatures of the line of 40° Range



To show the Variations in the January and July temperatures which form the lines of equal Range

Range on the Parallel of 50° N. Lat.



To show the Variations of Range in the same Latitude and the difference of Range on East and West Coasts

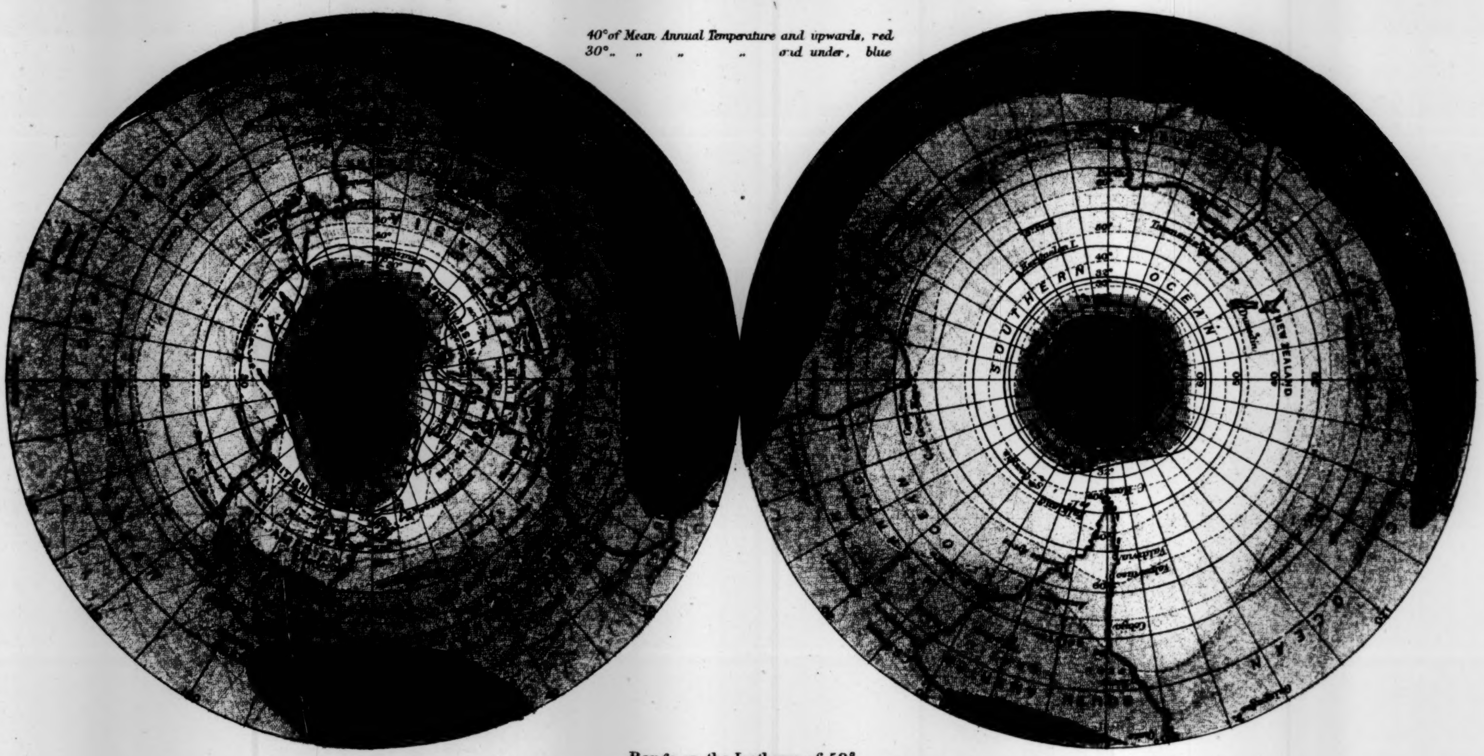
W. & A. K. Johnston, Edinburgh.

ANNUAL ISOTHERMAL LINES

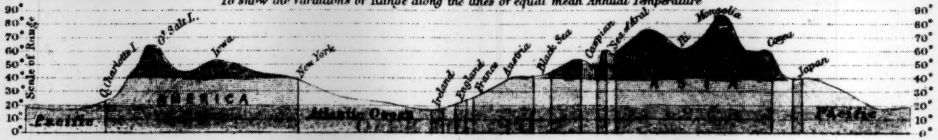
W.& A.K. Johnston, Edinburgh.

ANNUAL ISOTHERMAL LINES

40° of Mean Annual Temperature and upwards, red
30° „ „ „ and under, blue



Range on the Isotherm of 50°
To show the Variations of Range along the lines of equal mean Annual Temperature



W.& A.K. Johnston, Edinburgh.

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paralysing one. They have, besides, added minute quantities of strychnia to specimens of salts of methyl and of ethyl-strychnium of perfect purity, and they found that the effects which were then produced were exactly the same as those described by Messrs Jolyet and Cahours. The correctness of the statements previously communicated to this Society by the authors was thus established in the most undoubted manner.

In their first experiments with these strychnia derivatives, and especially with that formed by iodide of ethyl, the authors obtained results similar to those described by Messrs Jolyet and Cahours; and they have been induced to enter thus fully into the subject from the knowledge, gained by their experience, of the importance as well as of the difficulty of obtaining these bodies in a state of absolute purity. This is apparent if it be recollected that the presence of 0·1 per cent. of strychnia is sufficient to vitiate the results of such experiments. It was only after the authors had adopted precautions, which seemed at first to be perfectly unnecessary, that they succeeded in eliminating this source of error, and in obtaining their substances in a state of *physiological* purity.

The following Gentleman was elected a Fellow of the Society:—

Robert Henry Bow, Esq., C.E.

Monday, 31*st May* 1869.

Dr CHRISTISON, President, in the Chair.

The following Communications were read:—

1. On the Annual Range of Temperature over the Globe. By Mr Keith Johnston, jun. Communicated by Mr Buchan, Secretary of the Scottish Meteorological Society. (With a Plate.)

The subject of range of temperature has been divided by meteorologists into the two main heads of *Diurnal* and *Annual* range, the former being measured by the variation of temperature between the warmest and coldest hours of the day, the latter by the difference of temperature between the warmest and coldest months of the year.

For a study of *diurnal range* we should require a series of observations for every hour of the day and night from all parts of the earth, and the places where such laborious observations have been made are as yet very few; but the returns of daily and monthly temperatures now obtainable from all countries are sufficient for a tolerably complete study of the simpler head of *annual range.*

It is believed that the subject of annual range has never before been systematically worked out for any large portion of the earth's surface, though its general conditions may have been recognised from the comparison of a few isolated points.

In preparing the charts of annual range now shown, it was first assumed that the months of January and July are respectively the coldest and warmest months of the northern, and the warmest and coldest months of the southern hemisphere. This proves to be the case, with few exceptions, in all parts of the earth, excepting those near the equator, which have two maxima and minima; but the annual range of temperature in these regions is so very small, that the difference between the temperatures of January and July may be taken as the measure for every part of the earth where range is considerable. January and July temperatures were then collected from all available sources, and their differences being taken, the annual range of twelve hundred places in all countries was obtained. These figures were then set down on maps, on the positions of the places of observation, and lines were drawn through those which have an equal range, at intervals of ten degrees of increase,* thus presenting the subject in a graphic form. The places of observation in Europe are so numerous as to enable the lines to be laid down there with almost absolute precision. Then the collection of temperatures throughout the United States, Mexico, and the West Indies by Laurin Blodget, the returns from Canada and the Forts of the Hudson Bay Company, observations for a long series of years at the Danish stations in Western Greenland, and the numerous registers of temperature kept in vessels exploring the north-west passage, complete the lines for North America. In Asia the observations made at Russian government stations in Siberia in the north, at the ports of China and Japan on the east, at the Dutch Colonies in the East Indies, and in British India on the south, give the direction of these lines with certainty. For Africa we have the returns of numerous French stations in Algeria and Marocco, from Egypt, from the colonies on the Guinea Coast, from Cape Colony and Natal on the south, and a few checking points from the observations of travellers in Central Africa and Abyssinia. In South America the ascertained points are fewest; but observations made at the ports on both sides of the continent, from Panama to Patagonia, those of Ross in the Falkland Islands, a collection of temperatures in the Argentine Confederation given in the work on that country by M. Martin de Moussy, along with a few isolated points in Brazil, enable the range lines to be drawn here also with confidence. Lastly, for the coasts and south-eastern part of the interior of Australia, and for New Zealand, we have a large number of observations made chiefly by the Colonial Government. On the charts shown the parts of the earth's surface which have a *less* annual range than 40° have been tinted in *red*, the strength of the colour increasing as the range diminishes; and those regions which have a *greater* range than 40° in *blue*, the depth of colour increasing with the range.

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* In the reduced chart which accompanies this paper the lines of 10, 30, 50, 70, and 90 degrees of range have, for the sake of clearness, been omitted, but the course of these intermediate lines may perhaps be traced from the description which follows.

At the point where January and July, the coldest and warmest months of the northern hemisphere, turn to January, the warmest, and July, the coldest month of the southern hemisphere, we find a line passing round the globe on which there is no difference between the temperatures of these two months.

Starting from the first meridian we find this zero line passing along the Guinea Coast of Africa, through the centre of that continent, bent northwards by the table land of Abyssinia, and again by the Indian Ocean, entering India below Bombay and running curiously down the line of the Western Ghauts to Cape Comorin; then by the south of Sumatra through Java to New Caledonia, and across the Pacific between the parallels of 10° and 20° south latitude to the South American Coast, which it meets between latitude 5° and 10° south. Now it passes northwardly along the line of the Andes to Quito, and curves round the whole north coast of South America to beyond the mouth of the Amazon, then down into the South Atlantic to include the island of Ascension, which has a northerly range, and again northwards to the 20th parallel of north latitude, where it enters the African continent. It is observed that this zero line is very far from coincident with the mathematical equator of the globe, and that the parts of it which pass through the great land masses are in the northern hemisphere, in Africa, India, and South America, whilst those which pass through the Atlantic and Pacific Oceans are carried far into the southern hemisphere.

The line of 10° of range in the northern hemisphere passes through the centre of North Africa above Lake Tchad, is carried to the north by the influence of the Red Sea to beyond Djedda on its east coast, round the west and south coasts of Arabia, through Aden, and thence to India near the Gulf of Cutch. Here it reaches southward, taking the form of the peninsula, to beyond Madras, then crosses the Gulf of Bengal to Further India, passes round the coast of Cochin China and through the Philippine Islands in latitude 10° north, then turning to the north-east, keeps in this direction through the Pacific till it enters North America above the parallel of 40° north latitude; from that it turns down the coast of California to near the south of Mexico at Vera Cruz, through the West Indies just to the northward of Cuba, and across the Atlantic, with a northerly bend towards the Azores, to the African coast in latitude 25° north.

The line of 20° range in the northern hemisphere is one of the most interesting of all, since it shows in the most marked manner the difference of range between the west and east coasts of the continents. It passes through North Africa and Southern Asia, carried to the north at the Red Sea and Persian Gulf, leaves the east coast of Asia at Macao, near Hong-Kong, in 15° north latitude, runs well into the Pacific, keeping away from the Asiatic coast, and reaches the American west coast in latitude 55° north, or 40° further to the north than where it left the Asiatic coast, then it turns south to Mexico, across the north of the Gulf of Mexico to Florida, leaves the east coast between latitude 25° and 30° north, then into the Atlantic to the Bermudas, after which, bending due north-east, it reaches as far as Iceland, and perhaps Spitzbergen, before turning south to the Norway coast, again showing, as in the Pacific, a difference of 40° in latitude between the same range on an east and west coast. From the coast of Norway, at Stavanger, this line of 20° range dips down into the North Sea, then rises northwards along the coast of Scotland to Braemar in Aberdeenshire, bends thence to the west and south-west to between Glasgow and Greenock, then down the west coast of England by Liverpool and Chester, and Pembroke in South Wales, to Devonport on the coast of Cornwall, then along the south coast to the Isle of Wight and the Channel Islands, thus enclosing the main part of Great Britain with a greater range than Ireland, though the central and eastern parts of that island have a range of nearly 20°. The difference of range between the south-east coast of England and the west coast of Ireland is nearly 10°.

The line of 20° range then passes along the west coast of France and Spain, bending completely round the south-west and south coasts of the peninsula, through Lisbon, Cadiz, and Gibraltar into the Mediterranean, where it seems to form a great loop extending to the east nearly as far as Alexandria (21° range), touching in its return at Tunis, Algiers, and Oran in North Africa, and keeping along this coast as far as the Atlantic shores of Marocco, where it turns into the interior of Africa.

The line of 30° range runs through North Africa, Arabia, and Southern Asia to the north of the line of 20° range, and parallel to it, excepting in Northern India, where it forms a curious bend round the high mass of the Himalaya mountains, which appear to have a less range than is observed in the plain to the south of them. Leaving the Asiatic east coast, a little to the north of Canton, the line of 30° range passes between the Loo-Choo Islands and Japan, and thence north-easterly to the American coast, which it reaches just to the south of the peninsula of Aliaska. It runs southward along the west American coast, close to the line of 20° range, to near the 25th parallel of north latitude in Mexico; then bending round, first north and then east, follows along the coast of the Mexican Gulf and through the Southern States to Charleston on the east coast; from this it turns north-east and north, away from the east coast, but in its general direction, till it reaches land again at Godthaab on the west coast of Greenland; thence the line runs to the north-west of Iceland, and probably round Spitzbergen, turns south again to the coast of Norway at Hammerfest, follows down the whole west coast of Greenland, keeping near the head of the numerous fiords with which its coast is intersected, whilst the line of 20° range falls just at their mouths; through the Cattegat and Eastern Denmark, leaving Copenhagen just to the east of it; then following still the general direction of the west coast, though inland from it, runs through Brussels and Paris to the south of France. Here the range of the Pyrenees seems to cause a break—the greater elevation having a smaller range—and to isolate the portion of this line which passes round the Spanish peninsula. This separate portion of the line passes inland round the east and south coasts of Spain, but close to the north and west coasts. Taking up the main line again at Toulouse, we find it skirting the Mediterranean coasts of South France and Western Italy, through Genoa, Rome, and Naples, but leaving the east coast of Italy to cross the Adriatic to Dalmatia. A second small isolated part of this line is found in the eastern part of the island of Sicily, where Catania, on the east coast (on an average of sixty years' observations), has a range of 39°, whilst Palermo, on the north-west coast, has but 25°. From the Dalmatian coast the main line of 30° range turns to the south-east nearly through the centre of Greece and bends slightly north again in the Ægean to near Smyrna. A third isolated portion of this line is found in the south-east of the Black Sea, passing round Trebizond and along the coast of Caucasia. From the Ægean we find this line running through Cyprus to Syria, near Beyrout and Jerusalem, then turning west through the isthmus of Suez, just south of Cairo, and all along the north of Africa, not far inland from the coast, numerous observations in Algeria, showing that its average distance from the sea, in that country, is not more than 20 miles. On approaching the west coast it bends first south and then east into the centre of North Africa.

At 40° of range the lines begin to keep to the land masses—no part of the *open* ocean in any part of the globe having a range of more than 40°. In North Africa we find a large area of the Sahara with this range, where the north part of the line 40° reaches to within a hundred miles of the Mediterranean in Algeria, and extends probably south to the 20th parallel of north latitude. Taking up the line in Asia, we find it passing completely round the interior of Asia Minor, at no great distance from its coasts, then through Damascus into Arabia, round the head of the Persian Gulf, and through the Punjab, south of Peshawar, to the table-land of Tibet and the coast of China, near Shanghae; thence it turns north-east through the Yellow Sea to Hakodadi, in the north island of Japan, along the line of islands to the east coast of Kamtchatka, near Petropaulovsk, across the Behring Sea to Aliaska; thence down the west coast of America, close to the lines of less range, to the 35th parallel of north latitude, where it turns east across the continent to the west coast at Chesapeake Bay; thence it skirts the coasts of Nova Scotia, touches on Newfoundland at St John's, and, taking a northern direction, reaches the Greenland coast near Disco Island. Carried south by the influence of Greenland, it leaves the east coast, perhaps in the latitude of Iceland, and stretches thence probably beyond the North Pole, returning to the islands of Novaia Zemlia, where observation at two points gives a range of only 39°. From this the line of 40° range keeps near the north coast of Russia, and passes down through the centre of the Scandinavian Peninsula, by Christiana and Gottenburg to Stockholm, is carried northwards into the Gulf of Bothnia, then half way into the Gulf of Finland to Helsingfors, along the coasts of the Baltic provinces, and southwards through central Europe to Vienna. As we found the chain of the Pyrenees breaking the line of 30° range, so here we observe that the range of the Alps isolates the part of this line of 40°, which marks out the plain of Northern Italy. Another separate area, of above 40° range, is observed in the valley of the Ebro, in North-East Spain, and the heights of the Carpathians and Transylvanian Alps form a third exceptional portion of this line, since, though within the main line of 40°, they have a slightly less range. From Vienna the main line of 40° passes round the Hungarian plain, through Turkey to the north of the Balkan range, across the Black Sea south of the Crimea, into Trans Caucasia, nearly as far as Tiflis, and thence bends back again round the coasts of Asia Minor.

It is doubtful whether an area of any great extent, of above 50° of range, is to be found in Northern Africa, though one observation would seem to show that such does exist. The observed range at Biskra, in the interior of Algeria, is 54°; but since the observations at that station have not been made for any considerable period, no weight has been given to their indication. We find the line of 50° range entering Europe at the north of Norway, passing south to the centre of the Peninsula, then turning east to the coast at Hernösand, bent north by the Gulf of Bothnia to Carlö or the Finland coast, then turning south inland to near the Gulf of Finland, and again carried northward by the influence of the great Russian lakes; thence it passes southward midway between Moscow and St Petersburg to near the north-west side of the Black Sea, where it turns sharply to the eastward above the Black Sea and the Sea of Azov, and along the northern side of the ridge of the Caucasus to the Caspian. Round this sea the line of 50° range forms a loop which passes through the north-western part of the sea, but close to the remaining coasts, back to the south slope of the Caucasus; thence it passes westward through Erzerum into the interior of Asia Minor, curves round, and reversing its course, turns back into Asia through Persia, Tibet, and China to the eastern coast in the Yellow Sea, through the Corea, Saghalien Island, and Kamtchatka to the American coast at the mouth of the Kwichpak River in Alaska; thence southward into the interior of the continent to beyond the Great Salt Lake, where it turns to the east with two curious bends, and is carried to the north round the coasts of the great American lakes, only cutting off the north-west coast of Lake Superior with a greater range. It is curious to observe that the three greatest inland sea and lake regions in the northern hemisphere, the lakes of European Russia, the Caspian Sea, and the American lakes, have the same range of temperature; and that Fort-William, on the north-west coast of Lake Superior, has exactly the same range of 58°, observed at Astrakhan in the same relative position to the Caspian. From the Canadian side of the lakes near Ottawa, the line of 50° range bends south into the United States to as far as Albany in New York, then north-eastward through New Brunswick to the coast of Labrador, where three stations have this range. Keeping still northwards, it passes through Davis Strait to nearly as far north on the West Greenland coast at Upernivik, then through Greenland and round the Arctic Ocean, between North America and Asia (Point Barrow on the Arctic coast of North America having a range of 55°) to the Asiatic coast, probably near the mouth of the Obi river, and thence along the coast to the north of Norway, where we first took it up.

The line of 60° range, and those above it, are confined to the Asiatic and American Continents, and may be called land lines. Taking up the line of 60° of range in the north of European Russia, we observe it making a bend to the north-west round the town of Krasnoiarsk (which has a range of 65°) back again eastward to the Ural Mountains beyond Ufa, then forming a second western projection to as far as Kharkov, on the north of the Sea of Azov, then passing back round the east side of the Caspian Sea, and sending out a narrow tongue-like extension through Northern Persia and the town of Urumiah towards Asia Minor, then returning eastwards through Central Asia to the south of the town of Ili in Eastern Turkestan (62° range), through China, with a probable bend to the southward, rising again to near Pekin and Tientsin, through Manchuria, near its coasts, to Port Ayan (60°), on the Sea of Okhotsk; thence this line seems to pass round the north-eastern projection of Asia, and to turn westward through the Arctic Ocean, but not far from the land, to the north of the Ural Chain, where it enters Russia.

In America, taking up the line of 60° range at Port-Clarence on the coast of Behring Strait, we find it passing down into the interior to the east of British Columbia as far as Oregon, then following the same curves as the line of 50° range through the centre of the continent, to the north of the lakes, and bending round with the coast in Eastern Canada and Labrador, northwards through Melville Peninsula and Baffin Bay to Greenland in latitude 75° north. After passing through Greenland it most probably bends backwards along its north coasts and those of the islands of the Arctic Archipelago to where we find proofs of its existence in the westmost of these islands, thence to the north coast of America, along which it passes south from Point Barrow to Behring Strait.

A third area, which we find surrounded by a line of 60° range, is that in the north-east of Norway, in Lapland, and in the Kola

Peninsula. This line reaches as far south as Umea on the east coast of the Gulf of Bothnia, and passes just to the west of Tornea, at the head of the Gulf; thence across to the White Sea, and embracing the Kola Peninsula and the coast to westward of the Waranger Fiord, to where it enters Norway.

Beginning at Tobolsk in Siberia, we observe the line of 70° of range turning south-west to Orenburg and forming a western extension into European Russia, north of the Caspian Sea, as far as the Volga; thence round the north and east of the sea of Aral (where Raimsk has a range of 69°), and probably south from this into the deserts of Western Turkestan to the latitude of the south of the Caspian Sea; thence north-east through Barnaul on the Obi to the north of Krasnoiarsk on the Yenisei River (which has a range of 63°); south again through Irkutsk on the west side of Lake Baikal, probably to the northern frontier of China-proper, enclosing the desert of Mongolia; then north-eastward, taking the general direction of the coast to near Okhotsk (66° range). Afterwards bending round parallel with the line of 60° range this line must keep along near the north coast of Asia, re-entering the land at the Obi river and following along the east side of the Ural chain to where we found it first, at Tobolsk.

The American line of 70° range passes nearly parallel with that of 60° from near the coast at Behring Strait into the continent past the south end of Lake Winnipeg, and thence has most probably an extention into the mass of land to the west of Labrador, but avoiding the sea till it returns to the west coast of Hudson Bay, which it crosses near Fort-York; from this it passes north-east through Southampton Island and Boothia to where Kane wintered in Smith Sound, probably extends thence into Greenland, and turns back from there to Melville Island and Banks Land, through which it passes south-west into the mainland of America. A small and remarkable area in the north-east of Norway has also a range of above 70°. It extends from Enontekis (73° range) in the centre of Lapland on the south, to beyond Wardö, on the east coast of Norway, which latter place has a range of 78°.

From Tara, in the government of Tobolsk in Siberia, the Asiatic line of 80° range passes eastward to the north of Lake Baikal, and then south between that lake and the town of Chita, which has a range 85°, probably far into the desert of Mongolia, then north-eastwardly parallel with the lines of 70° and 60° range, but further inland to the north of Nijnie Kolymsk (85° range), and along the north coast westwardly to beyond the mouth of the Lena, where it probably re-enters the continent, and passes south-west through the government of Tobolsk to Tara. The observing stations on the chain of lakes in America which stretch north-west from Lake Winnipeg, have all a less range than 80° till we arrive at the most northerly, the Great Slave lake, whose north coast at Fort Confidence has this range; but two belts of country, one on each side of this lake-region, appear to have a range of upwards of 80°. These two belts unite at the north of the Great Slave lake, and stretch out thence westwards into Alaska territory, and eastward as far as Victoria Land and Boothia. A solitary observation of 93° of range, on the Yukon river in the centre of Alaska territory, might justify the enclosing of a small area in that region as having a range of above 90°, and this is certainly the part of the American continent which has the greatest range.

In Asia, the area which has a greater range than 90°, probably extends in Siberia from the Yenisei river on the west to the Stanovoi range of mountains in the east, and from near the north coast (where at Ust Yansk we find a range of 92°) to the Yablonoi range in the south. The town of Chita to the south of these mountains has a range of 85°. A smaller area in the interior of this one must be surrounded by a line of 100° of range. Near the centre of this terrible region is Yakutsk, the point of the earth's surface which has the greatest range of temperature, whose climate undergoes a change between the months of January and July of the fearful amount of 106 degrees.

In the Southern Hemisphere of range, the line of 10° seems to enter North Africa on the west coast not far north of Cape Colony, and to extend northwards into the centre of the continent to the north of the equator at Gondokoro on the Nile (whose January temperature is 11° above that of July), with a further extension towards the plateau of Abyssinia, since observations made by the traveller Bruce at Gondar give the January temperature at that place 8° above that of July. From this the line of 10° of range seems to keep due south, through Tete on the Zambesi to where it crosses the east coast in Natal; thence it passes over the Indian Ocean, with a slight bend to the northward south of the islands of St Denis and Bourbon, both of which have a range of 8°, to the south coast of Australia at Adelaide; from this, turning westward again, it runs along the south and west coasts, till, entering the latter coast about latitude 20° south, it crosses the north of the continent below the Gulf of Carpentaria into the Pacific, passes thence between New Caledonia and New Zealand, across the Pacific to the coast of South America southward of Valparaiso (9° range); thence it runs northwardly along the west coast of the continent to near Lima in latitude 12° south, bends up into the interior of the country, and crosses it in a general south-east direction to the east coast on the north of Rio de Janeiro (13° range), and finally passes over the Atlantic south-eastwardly to Africa.

The line of 20° range in the southern hemisphere is divided into three parts. The coasts of South Africa have nowhere an observed range of more than 16°; but in the interior an area showing slightly more than 20° of range extends from near the coasts of Cape Colony inland to perhaps 10° or 15° south latitude. Within Australia a line of 20° range passes from near Perth in Western Australia along the south coast, then close to the east coast (Brisbane and Newcastle showing 20° and 19° of range), and across the continent again westwardly near the parallel of 20° south latitude. The third line of 20° range enters the west coast of South America in about latitude 40° south, passes north near the coast to 25° south latitude, turns inland round the northern boundaries of the Argentine Confederation and Paraguay, and then curves round south and south-west to Monte Video on the east coast; thence it runs due south, round the Falkland Islands, which have a range of 16° to 18°, crosses the ocean towards the Cape of Good Hope, and thence east to New Zealand, passing through the south-eastern parts of both its islands, and from that over the Pacific to South America.

A line of 30° range follows close upon that of 20° in south Australia, and is probably confined to the southern half of the continent. In South America the range line of 30° passes along the west coast, perhaps from Cape Horn, northwards into the Argentine Confederation, through Catamarca and Santiago at its furthest north, returning thence perhaps outside the east coast.

The central and eastern parts of Patagonia have the highest range in the southern hemisphere, and this does not exceed 40°; observations at Mendoza in the north giving only 38° of range.

The lines of equal yearly temperature over the globe, or the annual isotherms, are sometimes termed "climate lines," and one is very apt to imagine that every place which lies under the same isotherm has the same climate, which is by no means the case. With a view to showing the variation of range in those parts of the earth which have the same mean annual temperature, six of the annual isotherms have been opened out, as it were, on each side of the meridian of Greenwich, and the amount of range for each point of these lines has been projected vertically above it, giving remarkable curves, of which the one shown beneath the chart of the annual isotherms* which accompanies this paper is a sample.

On the isotherm of 10° in the northern hemisphere, it is observed that the range may vary from 30° in the Arctic Ocean to above 100° in Eastern Siberia, near Yakutsk. The mean range on this isotherm is 65°.

The isotherm of 20° has also a mean range of 65°, but may have as little as 25° in the Arctic Ocean, and as much as 100° in Asia.

On the isotherm of 30°, or nearly a mean annual temperature of the freezing point, the range may vary from below 20° between Greenland and Norway, to above 90° in Eastern Asia, the mean range on this line being 60°.

The isotherm of 40° shows a variation of range of from less than 20° in the Atlantic Ocean south of Iceland and in the North Pacific, to above 80° in Mongolia; whilst the mean range is 47°.

The line of 50° of mean annual temperature has a mean range of 41°; but this varies between 20° in the west of Ireland, to above 80° in Asia.

On the isotherm of 60° we find a mean range of 40°, but only 10° in the Pacific, and above 70° in Central Asia.

From these curves then, it is evident that hardly any two regions having an equal mean temperature, even though of small extent, and at a very short distance from one another, have an equal amount of range, and that the places on the earth's surface in which these two conditions of equal mean annual temperature and equal annual range are the same, are very few and far between.

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* The annual isothermal lines shown on this chart are those of Dove, recently revised by Mr Buchan.

Again, to show the variations of range in the same latitude, some of the parallels of the northern hemisphere have been opened out, as the isotherms were in the former instance, on both sides of the first meridian, and the range on each point projected up from these as before, giving curves analagous to that shown below the southern hemisphere of the accompanying range chart.

One of the peculiarities shown by the curves thus produced, is that of the smallness of the range on seas and lakes, and the great amount on the land surface of the globe, as also the very immediate increase of range from some coasts towards the interior of the land. But by far the most interesting and curious feature presented by this diagram, or indeed by the whole subject, is that of the difference in the amount of range on the opposite coasts of continents and seas.

In the temperate regions, and even to some distance beyond these into the torrid zone and the arctic regions, *the range on coasts facing west is invariably less than that of coasts facing east, in the same latitude*, and this holds good not only in the case of great seas and land masses, but also on the shores of inland seas and lakes.

The comparison of the range at a few places in the same latitudes, but on the opposite coasts of the continents, given in the following tables, may serve to show the great amount of this difference.

In North America—

Latitude N.	West Coast.	Range.	East Coast.	Range.	Difference of Range.
57°	Sitka, . . .	23°	Port Nelson, Hudson Bay,	65°	42°
			Nain, Labrador,	52°	29°
43°	Port Orford, .	11°	Boston, . .	44°	33°
37° 30′	San Francisco,	8°	Richmond, Virginia, .	40°	32°
32° 30′	San Diego, California, . .	21°	Charleston, S. Carolina, .	31°	10°
			Mean Difference, ...		29°

The mean difference of these temperate coasts of North America, as determined by the crossings of the range lines on every fifth parallel of latitude, is 25°.

In Europe and Asia—

Latitude N.	West Coast.	Range.	East Coast.	Range.	Difference of Range.
60°	Bergen, Norway,	25°	Okhotsk, . .	66°	41°
57°	Riga, Russia, .	41°	PortAyan,Sea of Okhotsk,	60°	19°
	Mandal, Norway,	28°			32°
51°	Ostend, France,	26°	Mariinsk (Amur),	55°	29°
40°	Lisbon, . . .	15°	Pekin, . . .	56°	41°
31°	Jerusalem, . .	28°	Shanghae, . .	43°	15°
22°	Djedda, Arabia,	8°	Canton, . . .	35°	27°
			Mean Difference, ...		29°

The difference of range on these coasts, determined as before from the range lines, is again 25°, the same amount as we obtained for North America, thus establishing a close agreement in the relations of the coasts of these two continents.

The mean difference between the east and west coasts of that portion of North Africa which falls in the temperate regions is 10°, the Red Sea coast having that amount of range more than the Atlantic coast.

In South America we find Valparaiso in latitude 33° S. on the west coast, with a range of only 9°, and in latitude 35° S. on the east coast we have Monte Video and Buenos Ayres, with ranges of 21° and 25°, thus showing a difference between the coasts at this point of 14°. The range lines give a mean difference of 12°.

Observations on the west coast of South Africa, in the temperate region, are entirely wanting; but since the line of no January and July range falls 10° of latitude farther to the south in the Atlantic on the west, than it does on the east coast, where it just reaches the equator, we may perhaps assume that the west coast of South Africa has also a less range than the east, probably amounting to 5°.

In the temperate regions of South Australia the range lines give a mean difference between the coasts of 10°, the range on the *east* coast again predominating to this amount.

Taking a mean of all these differences, we find that, *in the temperate regions of the globe, the west coasts of the continents have* 15° *less range than the east coasts,* and we have seen that this difference may rise to above 40°.

An examination of the ranges on the coasts of inland seas, and even lakes, leads to the same general conclusion.

In the *Mediterranean* the following places—Alicante (30°), Valencia (40°), Barcelona (30°), Perpignan (36°), Montpellier (36°), Catania (39°), and Athens (38°), on *east* facing coasts, give a mean range of 36°; whilst Oran (21°), Algiers (21°), Palermo (25°), Naples (29°), Rome (30°), Corfu (28°), and Beyrout (28°), give a mean of 26° for the *west* facing coasts, or a difference of 10° between the two.

The mean of Odessa (47°) and Constantinople (33°) gives 40° of range for the *east* facing coast of the *Black Sea;* and Trebizond (29°) and Redut Kale in Caucasia (31°) give 30° as the range of the *west* facing coast; again showing a difference of 10° less on the latter coast. On the *east* facing coast of the *Caspian Sea,* taking the observations at Astrakhan and Lenkoran (58° and 42°), we have a mean of 50°, whilst Novo Petrovsk, the only observing station on the *west* facing coast, has 47° of range; Fort William (58°) and Bay City (55°) give 56° as the mean range of the *east* facing coast of *Lake Superior;* and Michipicoten, in the centre of its *west* facing coast, has only 46° of range, again showing a difference of 10°.

The causes of this uniform predominance of range on east coasts over west, might form an interesting subject for investigation. On no two continental coasts do we find exactly the same prevailing conditions of winds and currents, much less of elevation and form, so that the explanation of this phenomenon must rather be looked for in a special combination of these influences for each individual coast, than in any one cause acting over the whole earth's surface.

The lines of equal range are formed between different January and July temperatures in different parts of the globe. To show the manner in which these equal range lines move up and down the thermometer scale in their passage round the earth, a few of the range lines in the northern hemisphere have been opened out, as the isotherms were before, on each side of the meridian of Greenwich. The curved lines thus obtained, and of which a specimen is given under the northern hemisphere of the range chart, show the fluctuations of the temperatures forming the range lines of these amounts; the upper line shows the *July*, and the under line parallel to it the *January* temperatures, according to the scale shown at the side of the lines.

From this we observe that the line of 60° range lies between the temperatures of 30° Fahr. in January, and 90° Fahr. in July at its *maximum*, in Persia, and between – 20° Fahr. and + 40° Fahr. in Baffin Bay at its *minimum*.

The line of 50° of range, again, has its maximum in Central Asia between 40° Fahr. in January and 90° Fahr. in July, and its minimum in the Arctic Sea between – 15° Fahr. in January and + 35° Fahr. in July.

Forty degrees of range stands *highest* on the temperature scale in Arabia and Persia between 95° Fahr. in July, and 55° Fahr. in January; and is at its *lowest* point between – 5° Fahr. and + 35° Fahr. in the Arctic Sea.

The line of 30° of range has its maximum in Central Africa between 95° Fahr. and 65° Fahr. in July and January, and its minimum between + 5° and 35° in the North Atlantic.

Lastly, the line of 20° of range is at its highest temperature in Central Africa between 95° Fahr. and 75° Fahr. in July and January, and at its lowest in North Norway between 47° and 27° Fahr. The next lowest temperatures on the line of 20° fall in the British Isles, between 38° in January and 58° in July at Braemar in North Scotland, and 42° in January and 62° in July at Ventnor in South England.

The points on these lines which pass through the same isotherms, or whose January and July temperatures are at the same heights on the scale, have, so far as regards temperature, exactly the same yearly climate. Thus, on the line of 60° of range we may compare Minnesota in the United States with South Russia; on the line of 50° range, the Great Salt Lake region, in America, with the Caucasus in Europe; and the east coast of China in Asia, or the American Lake district, with that of North Russia. Again, on the line of 40° range, Newfoundland has exactly the same climate as the Baltic provinces of Russia, and the coasts of

Kamtschatka may be compared with those of North Norway, or *Hakodadi* in Japan with *Vienna* in Austria.

On the 30° range line we find the north coasts of British Columbia comparable with those of North Norway, *Paris* with *Fort Vancouver* in Oregon, and the south of Spain with the north of Mexico; and lastly, on the 20° range line, Macao Island near Hong Kong in China with the same climate as Florida in America.

A point worthy of notice, but for the establishment of which few data are as yet to be had, is that of the apparent diminution of range on elevated parts of mountains or mountain chains. The best authenticated example of this is that presented by the Alps of Switzerland. Observations for ten and twenty years at the St Gothard and St Bernhard hospices, at elevations of above 6000 feet, give a range of only 27° for each, whilst the plain of Italy to the south has a range of upwards of 40°. This diminution for elevation is also observed in stations in the Pyrenees, the Transylvanian Alps, and the Himalayas.

By the aid of these charts of annual range we can at once predicate of any point of the earth's surface whether it has a uniform and even climate, or an extreme one, or what precise place it holds between these limits. These charts may thus be of considerable utility in themselves, but it is when taken as companions to the annual isothermal charts, that they have their highest value. From the *isothermal chart* we may find that any required place has a certain mean yearly temperature; but we have no means of ascertaining from it how far the temperatures of its coldest month may descend, or how high its warmest month may ascend the thermometer scale. Again, from the *range chart* taken by itself, we can only tell that the climate of the place in question is limited to a certain number of degrees, without being able to say what position these degrees occupy in respect to heat and cold. But let the charts be used in company, and then we may have all that is required. First, from the one chart find the mean annual temperature of the place, and from the other its annual range; then, *since the mean annual temperature of places in the temperate and arctic regions of the globe corresponds very closely with the midway point between their January and July temperatures*—if the one-half of the amount of the range be placed *above* and the other half *below* the mean annual temperature on the thermometer scale, we have at once the temperatures of the warmest and coldest months, and the yearly temperature of the place, a knowledge sufficient for almost every purpose. This is best illustrated by an example. If we take from the isothermal chart the mean annual temperature of Paris, we find it 52°, and from the other chart its annual range is 30°; then the mean annual temperature *plus* the half of this range gives 67°, the July, and the mean annual *minus* half of the range, 37°, the January temperature of Paris.

In conclusion, it is submitted that the chart of annual range is a useful companion to the isothermal chart, and that used together these two form a very complete guide to the temperature of the globe.*

2. Note on Electrolytic Polarisation. By Professor Tait.

The following note refers to some experiments instituted at the request of Mr Dewar, who asked me to determine the polarisation of the Palladium electrodes whose singular behaviour he recently described to the Society.

I had just obtained one of Sir W. Thomson's most recent forms of quadrant electrometer, and it occurred to me that *this* must be the proper instrument for determining polarisation, as its indications are not affected by electric resistance, and give directly—that is, without assuming the truth of Ohm's law for reverse electromotive forces, and the consequent necessary determinations of resistance—the quantities required. The method employed by Wheatstone, Poggendorff, Buff, and others, assumes that the whole electromotive force in the circuit is the algebraic sum of those of the decomposing battery and of the electrodes,—an assumption whose truth some may consider to require proof, and which it is certainly useful to verify by an independent process. Again, after the decomposing action has ceased, the resistance of the films (of gas or oxide) which are deposited on the electrodes may change in value. That neither of these circumstances produces any marked effect is, however, amply proved by the numbers which follow, which, though given only as first approximations, are within the limits of difference of the results given (from galvanometric determinations) by former experimenters.

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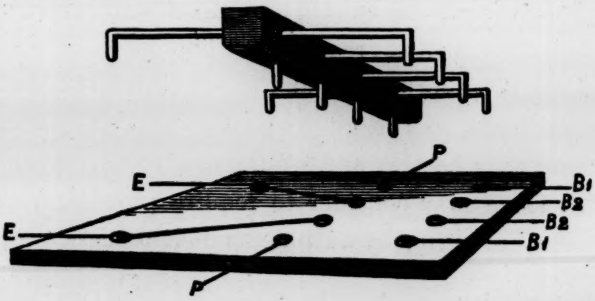
* The author has much pleasure in returning his best thanks to Mr Buchan, the Secretary of the Scottish Meteorological Society, for much assistance in the preparation of the materials for the chart, and for placing at his disposal a large private and unpublished collection of temperatures in all parts of the globe.

The experiments were all made in my laboratory, mainly under my own direction, but sometimes under the eye of my assistant, Mr W. R. Smith. Able assistance was rendered by several of my practical students,—two months ago by Messrs Russell Smith and J. C. Young, more recently by Messrs Browning and Nichol.

As the polarisation in most cases diminishes with very great rapidity from the instant of breaking contact with the decomposing battery, and as (for this and other reasons) the mode of measurement by the first swing of the index-needle of the electrometer is not deserving of much confidence, it was necessary to devise a process by which the electrometer could be charged at leisure up to any desired potential, and then, for an instant only, placed in connection with the electrodes. The apparatus I employed bears a certain analogy to the *wippe* of Poggendorff, but differs from it in some essential particulars, both of construction and mode of working.

In a plate of vulcanite, or other good insulator, ten holes are cut as below, and filled with mercury. Those marked E are connected



with pairs of opposite quadrants of the electrometer, P with the electrodes, B_1 with the decomposing battery, and B_2 with the auxiliary (or charging) battery. Also metallic connection, as indicated in the sketch, is permanently established between the two central holes and the holes connected with the electrometer.

The rocker consists of four wires, supported on an insulating bar of vulcanite, the two outermost having three points, the middle one longer than the others, and the two inner being similar, but wanting one of the extremities. When the four middle stems dip vertically into the four central mercury cups, the other stems do not reach the mercury in any of the other six cups. If the instrument be inclined to the right the four prongs enter the holes to the right—thus simultaneously connecting the electrodes with the decomposing battery, and the electrometer with the charging battery. When the instrument inclines to the left, the electrodes are shunted from the decomposing battery on to the electrometer,—the latter having just before, by the same action, been cut off from the charging battery, and thus left charged.

The *modus operandi* is simply this:—Leave the rocker leaning to the right by its own gravity, decomposition and polarisation going on; adjust the wires B_2 to different points in a wet string (or a narrow canal of water) closing the circuit of the charging battery; work the rocker quickly to the left, and allow it instantly to fall back again,—a process which need not occupy more than a small fraction of a second; yet which must not be performed too quickly, on account of the inertia (small as it is) of the needle and mirror of the electrometer. If the deflection of the electrometer be suddenly increased or diminished by this action, slide one of the wires B_2 along the wet string, a little farther from or nearer to the other, and rock again,—continuing this process till a charge is found which leaves the electrometer at rest when the rocking to and fro is performed. Reverse a commutator attached to the wires E, and repeat the operation. The difference of the scale readings in these two cases gives a number proportional to the electromotive force of the polarised plates—(I say *difference*, because the scales commonly used with Sir W. Thomson's instruments are, to avoid confusion, graduated from one end to the other, as they ought to be, instead of being graduated opposite ways from the middle). To enable this measure to be reduced to absolute units, a normal Daniell's cell was applied at intervals, during each day's work, directly to the electrodes of the electrometer, then reversed; and the difference of the readings was tabulated as representing its electromotive force.

In the earlier experiments I used a plate of gutta-percha in which the ten holes were bored, but for a time discontinued its use on suspecting that it sometimes led to irregular working of the apparatus by imperfect insulation. The cups were then *separately* mounted on insulators three inches high, but this was not found to be an improvement of any consequence; and the holes are now made in a small, but thick, plate of vulcanite.

In this note the numbers presented must be looked upon only as first approximations; but the apparatus has now been carefully constructed by an instrument maker, and Mr Dewar has begun an elaborate series of experiments with it, from which valuable results may soon be expected. In the trials which have as yet been made we employed a temporary apparatus, rudely built up of wires, sealing-wax, and gutta-percha. We have rather been endeavouring to determine whether the process, complicated as it is by the inertia of the movable part of the electrometer, the quickness with which the rocking can be conducted, and the rate at which the polarisation begins to diminish as soon as the polarised plates are detached from the decomposing battery, is capable of being made to give good results, than in actually attempting to get such. So far as I can yet see, the first of these complications is alone likely to cause any serious embarrassment; and should such be the case, which I do not anticipate, a form of experiment a little more laborious than that above described, and which I have already once or twice tried, seems to be well adapted to meet it.

The following are, for the most part, means of a great number of determinations. The electrolyte was usually dilute commercial sulphuric acid, 1 part acid to 10 of water; and to the lead and other impurities it was found to contain, we may ascribe the fact that the results were not very accordant from day to day, so that it was not easy to decide how to take the means. Mr Dewar is now working with substances chemically pure, and obtains much more constant results.

The unit employed is the electromotive force of an ordinary Daniell's cell. The Grove's cells used in the electrolysis had (very constantly) an electromotive force about 1·74 times as great.

I. FRESHLY BURNED PLATINUM PLATES.

No. of Grove's cells in decomposing battery, . . .	1	2	3	4	8
Resulting polarisation, . .	1·64	1·98	2·01	2·12	2·30

II. PLATINUM +, PALLADIUM −.

Cells, ...	1	2	4
Polarisation, ...	1·50	1·82	1·85

III. PALLADIUM +, PLATINUM −.

Cells, ...	1	2	4
Polarisation, ...	1·60	1·92	1·91 (?)

IV. WITH THREE CELLS.

	Platinum +, Iron −.	Platinum −, Iron +.	Iron Plates.
Polarisation, .	2·16	0·0	0·0

V. ALUMINIUM PLATES.

Cells, ...	1	2	3	4	6
Polarisation, . .	1·09	2·17	2·44 (?)	4·01	5·20

The last results are very remarkable, showing, as they do, from aluminium electrodes a reverse electromotive force of more than five Daniell's when six Grove's are in circuit. The polarisation alters so rapidly during the electrolysis (in the case of aluminium) that I cannot be certain that the numbers above given represent fully the maximum effect. Various other combinations have been tried, but are being repeated by Mr Dewar.

3. On the Causes of Volcanic Action. By Joseph John Murphy, Esq. Communicated by Dr Wyville Thomson.

In offering these remarks on the causes of volcanic action, I take it as proved that volcanoes are in communication with a reservoir of heat, occupying the centre of the earth: which heat, however, the earth is gradually, though very slowly, losing; partly by volcanic eruptions, partly by hot springs, and partly by the slow conduction of heat towards the surface through the strata.

I also take it as proved, that the earth is not fluid but solid throughout; or, at least, that its solid crust is of such thickness that the earth is to be regarded for all purposes as a solid body. Consequently the production of lava—that is to say, the liquefaction from heat of a small portion of the solid mass of the earth—is a strictly local occurrence; this is sufficiently proved by the well-known fact, that the lava stands at different levels in different volcanic craters, even when they are in eruption at the same time, and very near each other: as in the case of Mauna-Loa and Kilanea, in Hawaii (Scrope on Volcanoes, p. 262), which would be impossible if there were any free hydraulic communication between the different reservoirs of lava. The strata at great depth, notwithstanding their intense heat, are kept solid, as we have every reason to believe, by the pressure of the superincumbent strata, and *their liquefaction in particular places, producing lava, is due*, as I shall endeavour to prove, *to local relief from pressure.*

Darwin has brought forward what appears to be nearly conclusive evidence for believing that active volcanoes are to be found only in areas that are undergoing elevation. To quote his own words:—

"It may, I think, be considered as almost established, that volcanoes are often (not necessarily always) present in those areas where the subterranean motive power has lately forced, or is now forcing outwards the crust of the earth, but that they are invariably absent in those where the surface has lately subsided or is still subsiding."—Darwin on Coral Islands, p. 142.

It appears to be generally taken for granted that the expansive force of the earth's internal heat is the motive power that produces elevation, and also volcanic action. In this theory, however, there is a difficulty which is not, I think, generally perceived. At the beginning of geological time, the earth must have been sufficiently cooled down to permit the formation over its surface of a cold solid stratum. The lower strata are not hotter now than they were then, and may perhaps be *sensibly* colder, as they are constantly, though very slowly, parting with heat. If, then, the temperature of the lower strata, millions of ages ago, was low enough to permit a cold solid crust to form above them, how can it now, when it has not risen, be high enough to raise up that crust in upheavals, and break through it in eruptions? It seems almost a contradiction to think this possible. To use a familiar illustration:—When an iron casting is cooling in the sand, and, of course, like the earth, cooling from the surface; when once the cold hard crust begins to form, the greater heat of the interior has no tendency whatever to break through the crust. Were there no other force to upheave, or break through the earth's crust, I do not believe the internal heat could ever do it. I have now to state how I believe such actions are brought about.

The earth is cooling, and as it cools it must contract. But this is true only of the deeper strata: the surface is cooling and contracting no longer. But the surface, by reason of its weight, is clinging round the centre.

The earth is a sphere, whereof the centre is contracting, while the surface clings to the centre and yet cannot contract. What, then, will necessarily follow? The same that happens when an apple contracts, while its skin clings to it and yet cannot contract—the surface will form *wrinkles*, rising in some places and sinking in others. This, I believe, is the explanation of those gradual movements of elevation and subsidence, which, as we know, have taken place everywhere, and are now going on at least over extensive areas. But the formation of mountain chains having axes of igneous rocks, and of volcanoes, needs further explanation.

Over areas of elevation the superficial strata are, in a slight degree, being lifted up; over areas of subsidence they are, in an equal degree, being forced down. When they are lifted up, there will be a diminution of pressure on the lower strata. (This may be made evident by considering that if the upper strata were lifted up into an arch, which, however, is probably impossible, they would not press on the lower strata at all.) A diminution of pressure on the lower heated strata will cause them to melt into lava, expanding at the same time (igneous rocks, in the act of melting, expand by from a ninth to a third of their volume when unmelted—Bischoff, quoted in Scrope on Volcanoes, p. 44), and the same cause will make their imprisoned vapours expand. (For the existence of these vapours, see Scrope on Volcanoes, p. 56.) This action probably begins suddenly, as soon as the diminution of pressure is sufficient to permit the rocks to begin to melt. In this way, as I believe, the igneous axes of mountain chains have been thrust up. Two causes there are which so operate—the general subsidence of the crust of the earth, thrusting it in particular places over regions of elevation, into huge anticlinal wrinkles, and the expansive force of the heat from below, *when once liberated* by local relief from pressure. The former, as I have explained above, is what determines igneous action in any particular place; the latter accounts for all violent action, such as highly inclined and overturned strata; without it there would be no mountains, but only gentle elevations.

A volcano is formed whenever the igneous matter from below either forces its way to the surface, or (what is perhaps a possible case) has way made for it through a crack in the superficial strata, formed as they bend into wrinkles. But the fact that volcanoes are found only in regions of elevation, proves to my mind that the first determining cause of volcanic action is the elevation, causing local relief from pressure, and enabling the solids and vapours to expand from the heat they contain.

Proof has been found of the existence of active and recent volcanoes in the heart of the Asiatic and North American continents (see Scrope on Volcanoes, pp. 405, 453), but they are very much more numerous on islands and coasts. There must be some reason for this, and, I believe, the reason is, that the ocean is the great agent of denudation and deposition; consequently changes in the weight pressing on the various positions of the bed of the ocean are constantly taking place, and such changes cannot fail to cause changes in the limits of the areas of elevation and subsidence, and to produce irregularity in the wrinkling action; and the more of such changes and irregularities there are, the more multiplied will be the chances of local diminution of pressure sufficient to cause volcanic action. Over great continental areas, on the contrary, the wrinkling action will be undisturbed, and will go on for the most part more evenly, though it will still produce igneous action in some cases.

4. Preliminary Note on the Antagonism between the Actions of Physostigma (Calabar Bean) and Belladonna. By Dr Thomas R. Fraser.

(*Abstract.*)

In this paper the author described a number of observations which appear to demonstrate that the fatal action of certain doses of physostigma may be prevented by the administration of atropia.

The following plan was adopted for the investigation:—After the minimum fatal dose of each poison had been approximately determined for rabbits and dogs of different weights, a fatal dose of one of the poisons was administered along with a certain dose of the other, and, if death did not result, the same animal was subsequently killed by a dose of one of the poisons equal to or less than that given in the combination.

To illustrate the general character of the results, the following experiments, among others, were described:—

Experiment 1.—A solution of four grains of sulphate of atropia, in twenty minims of distilled water, was injected under the skin at the left flank of a young rabbit, and, immediately afterwards, a solution of 0·5 gr. of physostigma, in fifteen minims of distilled water, was injected under the skin at the opposite flank. In two minutes the pupils were dilated. Fibrillary twitches then occurred, and in about ten minutes paralysis was present to such a decided extent that the rabbit had great difficulty in moving about, and usually lay extended on the abdomen and chest, with the head resting on the lower law. It continued in this state for about twenty minutes, and then the symptoms gradually disappeared; so that, in rather more than an hour and thirty minutes after the injections, it appeared to have recovered perfectly, with the exception that the pupil-dilatation remained.

Experiment 2.—Several days subsequently, 0·5 grain of extract of physostigma, in fifteen minims of distilled water, was injected under the skin of this animal. Death occurred in fifteen minutes.

Experiment 3.—In the next experiment, a rabbit of nearly the same weight as that used in the last received six grains of sulphate of atropia, and then 0·5 grain of extract of physostigma. The symptoms were less serious and of shorter duration than in the

experiment where the same dose of extract of physostigma was given along with only four grains of sulphate of atropia, and they appeared to be caused by the latter substance chiefly.

Experiment 4.—Four days afterwards, it was found that 0·5 grain of extract of physostigma was a fatal dose for this rabbit also.

Evidence of a still more satisfactory character in support of the result that the toxic action of physostigma may be prevented by atropia was obtained with dogs.

Experiment 5.—Eight grains of sulphate of atropia and three grains of extract of physostigma, in distilled water, were injected under the skin of a vigorous English terrier dog, weighing ten pounds. The chief symptoms were dilatation of the pupils, partial paralysis, and hypnotism. Of these, the first continued for several days, and the last for less than twenty-four hours. The partial paralysis continued for only forty minutes, after which the dog was in a perfectly normal condition, except that the pupils were in full dilatation, and that a tendency to indulge in sleep was manifested.

Experiment 6.—Three weeks afterwards, the same dog received eight grains of sulphate of atropia and six grains of extract of physostigma—the latter being twice as large a dose as that given in the previous experiment. Dilatation of the pupils and considerable loss of motor power were again produced; but, in addition, certain symptoms were prominently exhibited that were undoubtedly due to the physostigma, such as tremors and exaggerated bronchial secretion. The partial paralysis and tremors continued for more than three hours, and the dilatation of the pupils for several days, after which the dog perfectly regained its former condition.

Experiment 7.—In order to show distinctly that the atropia had prevented the fatal action of the physostigma given in these two experiments, this dog received, some weeks afterwards, three grains of extract of physostigma—a dose equal to that from which it recovered in the first experiment, and *only half* as large as that from which it recovered in the second. The results were that partial paralysis and tremors were quickly produced, that the lachrymal and salivary secretions were profusely increased, and that the respirations became more and more laboured and jerking, until they ceased in death, at seventeen minutes after the administration.

These experiments appear to prove that in rabbits and dogs the fatal action of certain doses of physostigma may be prevented by atropia.

Many examples can be referred to in which several of the actions of various substances may be impeded, prevented, or counteracted by those of others. Of these we may instance the antagonism between the actions of physostigma and atropia and of opium and atropia on the iris, and also of these pairs of substances and of quinia and morphia on the minute blood-vessels. It is, however, doubtful if any absolutely demonstrated example of antagonism can be referred to in which the toxic action of one substance may be prevented by the physiological action of another. The only instance deserving of notice in which antagonism of the latter class is asserted to exist, is that between opium on the one hand, and belladonna, hyosciamus, and other active substances derived from the *Solanaceæ* on the other. The truth of this reputed antagonism has not, however, been established. The observations on man that appear to support it are found, on careful examination, to be liable to many objections; while the experiments that have been made on the lower animals have produced evidence that is directly opposed to its existence.

In bringing these experiments before the Society the author's purpose has only been to show that there exists an antagonism between the toxic action of certain doses of physostigma and of belladonna or atropia. In the further investigation of this subject it will be necessary to determine exactly on what special actions this antagonism depends, and also within what limits of dosage it is maintained. Being concerned with two substances each of which possesses a number of actions, it is not unreasonable to anticipate that several of them are not mutually antagonistic. Above certain doses a region may, therefore, be entered where the non-antagonised actions are present in sufficient degrees to be themselves able to produce fatal effects.

These, and many other important questions, remain for examination. Their elucidation may be expected to have a direct bearing on the principles of therapeutics, for they require the demonstration of the manner in which certain accurately defined abnormal conditions are restored to normality by actions of an equally defined and accurately determined character.

In the meantime, the few facts that have been obtained indicate a valuable practical application. Although the existence of an antagonism between the fatal effects of physostigma and belladonna has been ascertained by experiments on rabbits and dogs only, there is no reason to doubt that it will be found to exist in man also. We may thus have at our disposal a physiological antidote for physostigma-poisoning, occasion for applying which may occur in this country, and already daily occurs in West Africa, where physostigma is extensively used as an ordeal poison.

5. On the Thermal Energy of Molecular Vortices. By W. J. Macquorn Rankine, C.E., LL.D., F.R.SS. Lond. and Edin., &c.

(*Abstract.*)

In a previous paper, presented to the Royal Society of Edinburgh in December 1849, and read on the 5th of February 1850 (Trans. vol. xx.), the author deduced the principles of thermodynamics, and various properties of elastic fluids, from the hypothesis of molecular vortices, under certain special suppositions as to the figure and arrangement of the vortices, and as to the properties of the matter which moves in them. In subsequent papers, he showed how the hypothesis might be simplified, by dispensing with some of the special suppositions. In the present paper he makes further progress in the same direction, and shows how the general equation of thermodynamics, and other propositions, are deduced from the hypothesis of molecular vortices when freed from all special suppositions as to the figure and arrangement of the vortices, and the properties of the matter that moves in them, and reduced simply to the following form: *that thermometric heat consists in a motion of the particles of bodies in circulating streams, with a velocity either constant or fluctuating periodically.* This, of course, implies that the forces acting amongst those particles are capable of transmitting that motion.

The principal conclusions arrived at are the following:—

1. In a substance in which the action of the vortices is isotropic, the intensity of the centrifugal pressure per unit of area is *two-thirds* of the energy due to the steady circulation in an unit of

volume. The centrifugal pressure is the pressure exerted by the substance in the perfectly gaseous state.

2.* If there be substances in which the action of the vortices is not isotropic, then in such substances the proportion already stated applies to the mean of the intensities of the centrifugal pressures in any three orthogonal directions.

3.* The proportion which the whole energy of the vortices, including that of the periodic disturbances, bears to the energy of the steady circulation alone, may be constant or variable.

4. Absolute temperature is proportional to the energy of the steady circulation in unity of mass, and to the specific volume in the perfectly gaseous state.

5. In substances which are nearly in the perfectly gaseous state, experiment shows the proportion in which the whole energy exceeds that of the steady circulation to be sensibly constant; and its value may be found by computing in what proportion the dynamical value of the specific heat at constant volume exceeds once and a half the quotient found by dividing the product of the pressure and volume by the absolute temperature. *The following are examples:—air, 1·634; nitrogen, 1·630; oxygen, 1·667; hydrogen, 1·614; steam-gas, 2·242.

6. The known general equation of thermodynamics is deduced from the hypothesis of molecular vortices,* freed from the special suppositions made in the paper of 1849–50.

The new conclusions obtained in the present paper are marked *. Those not so marked were arrived at in the paper of 1849–50.

[The general equation of thermodynamics is here stated for convenience; let $d\mathrm{Q}$ be the thermal energy which must be given to unity of mass of a given substance, in order to produce a given indefinitely small change in its temperature and dimensions: then—

$$d\mathrm{Q} = \tau\, d \cdot \phi;$$

in which τ is the absolute temperature, and ϕ the thermodynamic function. The value of that function is—

$$\phi = \mathrm{J}c \text{ hyplog } \tau + \chi(\tau) + \frac{d\mathrm{U}}{d\tau};$$

Jc being the dynamical value of the real specific heat; U, the potential energy of the elasticity of the body at constant temperature; and $\chi(\tau)$, a function of the absolute temperature, which is null or inappreciable in a substance capable, at that temperature, of approximating indefinitely to the perfectly gaseous state, and is included in the formula, in order to provide for the possibility, suggested by Clausius, that there may be substances which have not that property at all temperatures].

6. On the Rotation of a Rigid Body round a Fixed Point. Part II. By Professor Tait.

The following Gentlemen were elected Fellows of the Society:—

MAURICE LOTHIAN, Esq.
JOHN MACLAREN, Esq.

The following Donations to the Library were announced:—

Abbe (Cleveland). Dorpat and Poulkova. Washington, 1867. 8vo.—*From the Author.*

Baars (Herman). Berelning om den Internationale Fiskerindstilling i Boulogne-sur-Mer, 1866. 12mo.—*From the Author.*

——— Les Pêches de la Norwége. Boulogne-sur-Mer, 1866. 8vo.—*From the Author.*

Bigsby (John J.), M.D., F.G.S. Flora and Fauna of the Silurian Period, with Addenda. London, 1868. 4to.—*From the Author.*

Broch (Dr O. J.). Traité Élémentaire des Fonctions Elliptiques. Fasc. II. Christiania, 1867. 8vo.—*From the Author.*

Brown (Robert). Das Innere der Vancouver-Insel. 4to. Being a German translation of his paper.—*Fro m Author.*

Castello de Paiva (Barone de). Monographia Molluscorum Terrestrium, Fluvialium, Lacustrium, Insularium Maderensium. Olisipone, 1867. 4to—*From the Author.*

Cohen (Henri). Description des Médailles Grecques, Romaines, etc. Paris, 1869. 8vo.—*From the Author.*

Day (St John Vincent), C.E. Malleable Iron Manufacture and the Richardson Process. Glasgow, 1868. 8vo.—*From the Author.*

——— Present State of some Branches of Iron Metallurgy. Glasgow, 1868. 8vo.—*From the Author.*

Dorna (Alessandro, Prof.). Catalogo delle Leoneidi o Stelle Meteoriche del periodo di Novembre Osservate nel 1867 al regio Osservatorio di Torino. 4to—*From the Author.*

Erdmann (A.). Sveriges Geologiska Undersökning pa offentlig bekostnad Utförd under ledning af A. Erdmann. Nos. 26–30, with Charts. 8vo.—*From the Editor.*

Geikie (Archibald), F.R.S. Memoir of the late James David Forbes, D.C.L., LL.D., F.R.S. Edinburgh, 1869. 8vo.—*From the Author.*

Handyside (Dr). Observations on Arrested Twin-Development. 8vo.—*From the Author.*

Hertzberg (N.). Indberetning om nogle Lærerseminarier i premmede Lande fra en Reise 1866 og 1867. Christiania, 1868. 8vo.—*From the Author.*

Hirsch (A.) et Plantamour (E.). Nivellement de précision de la Suisse, exécuté par la Commission Géodésique Fédérale sous la direction des auteurs. Liv. I. Genève, 1868. 4to.—*From the Authors.*

Jenkin (Fleeming). On the Education of Civil and Mechanical Engineers. Edinburgh, 1868. 8vo.—*From the Author.*

Journal (American) of Science and Arts. Conducted by Benjamin Silliman. Nos. 138, 139, 140. New Haven. 8vo.—*From the Editor.*

Kronecker (L.). Uber Systeme von Functionen mehrer Variabeln. Berlin, 1869. 8vo.—*From the Author.*

Lawson's Pinetum Britannicum. Parts XXXI. and XXXII. Edinburgh. Fol.—*From Charles Lawson, Esq.*

Maclaren (Charles). Select Writings. Edited by Robert Cox, F.S.A., and James Nicol, F.R.S.E. Vols. I. and II. 8vo.—*From Mrs Maclaren.*

Mailly (Ed.). L'Espagne Scientifique. Brussels, 1868. 12mo.—*From the Author.*

Manuscripts. Facsimiles of National Manuscripts of England. Selected under the direction of Colonel Sir Henry James. Part IV. Fol.—*From the Secretary of State for War.*

Nomenclature of Diseases, drawn up by a Joint-Committee appointed by the Royal College of Physicians of London. London, 1869. 8vo.—*From the College.*

Plantamour (E.). Résume Météorologique de l'Année 1866 et 1867 pour Genève et le Grand Saint-Bernard. 8vo.—*From the Author.*

Quatrefages (M. de). Observations relatives à un ouvrage de M. Claparède, intitulé Les Annélides Chétopodes du Golfe de Naples, et Réponse à ses Critiques. Paris. 4to.—*From the Author.*

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INDEX.

Address on recent Scientific Researches in Palestine, 271.
Aerial Blue, Colour of, 430.
Akazga Ordeal of West Africa, noticed, 159.
Alexander (Colonel Sir J. E.), Observations on the desirableness of transporting from Alexandria to Britain the prostrate Obelisk presented to George IV. by Mahomed Ali Pasha, 284.
Alison (Sir Archibald), Obituary Notice of, 185.
Allman (Professor), Obituary Notice of Dr John Davy, 288.
——— on Rhabdopleura, a new Genus of Polyzoa, 438.
——— Address on Anthropoid Apes, chiefly in reference to Specimens recently acquired by the Edinburgh Museum of Science and Art, 501.
Ammonia, its Action on Dichloracetone, 75, 133.
——— Formation of, when Nitrogen and Aqueous Vapour are passed over Magnesium, 536.
——— Physiological Action of the Salts of, 556.
An-atomic or Transmissible Power, 512, 539.
Anderson (Professor Thomas) on the Products of the Destructive Distillation of Animal Substances. Part V. Action of Sodium on Pyridine, 379.
Animal Electricity, 63.
——— Power, its Nature and Source, 539.
Annelids, New British, 379.
Anthropoid Apes, 501.
Antiquities, Scenery, &c., of Cambodia illustrated, 112.
Antiquity of Intellectual Man, 226.
Archer (T. C.), Note on an undescribed Variety of Flexible Sandstone, 485.
Arctic Shell-Clay of Elie and Errol, 107.
Atmospheric Pressure, over the Globe for the Months and for the Year. Part I., 303.
——— Mean, 523.
Atropia, its Action in Cold-Blooded Animals, 434.
——— and Conia, Physiological Action of the Salts of the Ammonium Bases derived from, 461.

Bache (Alexander Dallas), Obituary Notice of, 187.
Balfour (Professor), Observations on the Spores of Cryptogamic Plants, and on the Reproductive Process in some Algæ and Fungi, 294.
Barnes (Dr Henry), an Account of some peculiarly-shaped Mineral Concretions found near Carlisle, 120.
Bebeeru Wood, Alkaloids contained in, 548.
Belladonna and Calabar Bean, Antagonism between the Actions of, 587.
Bennett (Dr J. Hughes), Address on the Progress of Physiology, 63.
Black (James), Obituary Notice of, 188.
Blackie (Professor) on the Sophists of the Fifth Century B.C., 119.
Blood, Effect of Reduction of Temperature on the Coagulation of. 157.
Bonar (Wm.), Obituary Notice of, 33.
Boulder-Clay of Europe, 529.
Brande (Wm. Thomas), Obituary Notice of, 34.
Brewster (Sir David) on the Colours of the Soap Bubble, 64.
——— on the Figures of Equilibrium of Liquid Films, 76.
——— on the Motions and Colours upon Films of Alcohol, Volatile Oils, and other Fluids, 108.
——— on the Vapour Lines in the Spectrum, 145.
——— on the Radiant Spectrum, 147.

Brewster (Sir David), Description of a Double and Triple Holophote, and of a Method of Introducing the Electric and other Lights, 157.
——— Opening Addresses, 2. 173.
——— Obituary Notice of, 282.
——— Minute in reference to his Death, 284.
——— on the Figures of Equilibrium of Liquid Films, 311.
Broun (J. Allan), Note upon a Method of Varying Weights by Minute Quantities, 167.
——— on the Diurnal Variations of the Magnetic Declination near the Magnetic Equator, and in both Hemispheres, 168.
Brown (Dr A. Crum), Note on the Action of Ammonia on Dichloracetone, 75, 133.
——— on an Application of Mathematics to Chemistry, 89.
——— on Chemical Structure, 518.
Brown (Dr A. Crum) and Dr T. R. Fraser on the Changes produced by direct Chemical Additions on the Physiological Action of certain Poisons, 228, 461, 556.
——— on the Physiological Action of the Salts of Ammonium Bases derived from Atropia and Conia, 461
——— (Professor A. Crum) and Dr T. R. Fraser on the Physiological Action of the Salts of Ammonia, of Tri-methylamine, and of Tetra-methyl-ammonium; of the Salts of Tropia, and of the Ammonium Bases derived from it; and of Tropic, Atropic, and Isatropic Acids and their Salts, &c., 556.
——— on the Physiological Action of the Salts of Methyl-Strychnium and of Ethyl-Strychnium, 556.
Brown (Rev. Thomas) on the Arctic Shell-Clay of Elie and Errol, viewed in connection with our other Glacial and more recent Deposits, 107.
Bryson (Alexander), Obituary Notice of, 189.
Buchan (Alexander), the Mean Pressure of the Atmosphere over the Globe for the Months and for the Year. Part I.—January, July, and the Year, 303.
——— on the Determination of Heights, chiefly in the Interior of Continents, from Observations of Atmospheric Pressure, 465.
Buchan (Alexander) on the Mean Pressure of the Atmosphere and the prevailing Winds for the Month and for the Year. Part II., 523.
Burning Mirrors of Archimedes, and on the Concentration of Light produced by Reflectors, 232.
Burt (John G. M.), Obituary Notice of, 282.

Cable-Testing, Address on, 454.
Calabar Bean, Physiological Action of the, 51.
Calabar Bean and Belladonna, Antagonism between the Actions of, 587.
Campbell (John A.), Obituary Notice of, 20.
Catton (A. R.), Note on a former Paper on the Theory of Double Refraction, 159.
——— on the small Oscillations of Heterogeneous Interpenetrating Systems of Particles, which act upon each other according to Laws dependent only on their Mutual Distances, 165.
——— on the Theory of the Formation of Ammonia when Nitrogen and Aqueous Vapour are passed over Magnesium, 536.
Cay (John), Obituary Note of, 19.
Cayley (Professor) on Polyzomal Curves, 217.
Centres, Faisceaux, and Envelopes of Homology, 134.
Centrifugal Governors, Intensified Gravity in, 477.
Chemical Structure, 518.
Christison (Professor), Opening Address, 392.
——— Notice of a remarkable Mirage observed in the Firth of Forth, 472.
Colour and Motion on Films of Alcohol, Volatile Oils, and other Fluids, 108.
Comets, 553.
Conia and Atropia, Physiological Action of the Salts of the Ammonium Bases derived from, 461.
Council, 1866-67, 1867-68, 1868-69, 1, 173, 391.
Cousin (Victor), Obituary Notice of, 190.
Craigie (David), Obituary Notice of, 15.
Cryptogamic Plants, Spores of, and Reproductive Process in, 294.

Danube, Improvement of, 313.
Davy (Dr John) on the Effect of Reduction of Temperature on the Coagulation of the Blood, 157.
——— on the Temperature of the Common Fowl (*Gallus domesticus*), 288.
——— Obituary Notice of, 288.
Determinants of the Third Order, 59.
Dewar (James) on the Oxidation of Phenyl-Alcohol, and a Mechanical Arrangement adapted to illustrate Structure in the non-saturated Hydrocarbons, 82.
——— on the Motion of a Palladium Plate during the formation of Graham's Hydrogenium, 504.
Dewar (James) and Dittmar (William) on a Derivative of Meconic Acid, 129.
Dickson (Professor Alexander) on the development of the Flower of *Pinguicula vulgaris*, L., with Remarks on the Embryos of *P. vulgaris*, *P. grandiflora*, *P. lusitanica*, *P. caudata*, and *Utricularia minor*, 531.
Dittmar (W.) on the Analyses of Compound Ethers, 126.
Dittmar (W.) and Dewar (James) on a Derivative of Meconic Acid, 129.
Double Refraction, Theory of, 159.
Duncan (James), Obituary Notice of, 18.
Duncan (Dr J. Matthews) on a Lower Limit to the Power exerted in the Function of Parturition, 163.

Electrolytic Polarisation, 579.
Energy, Dissipation of, 309.
Ethers, Compound, Analyses of, 126.
Ethyl-Strychnium, Physiological Action of the Salts of, 556.
European Winter Storms, Nature and Character of, 140.
Faraday (Michael), Obituary Notice of, 192.
Fellows Elected, 61, 70, 86, 105, 112, 125, 139, 156, 169, 204, 242, 282, 302, 311, 313, 379, 430, 440, 461, 476, 485, 501, 504, 517, 523, 561, 592.
Films of Alcohol, Motions and Colours upon, 108.
Firth of Forth, Basin of the, 550.
Flow of Solids, &c., 311.
Fœtal Heart, Transitions in the, 499.
——— Growth and Development of, 519.
Forbes (Principal), Notice of his Death, 453.
——— Minute in reference to his Death, 476.
Forbes (Sir John H. S.), Obituary Notice of, 16.
Fraser (Thomas R., M.D.), on the Physiological Action of the Calabar Bean (*Physostigma venenosum*, Balf.), 51.
——— a Preliminary Notice on the Akazga Ordeal of West Africa, and its Active Principle, 159.
——— an Investigation into some previously undescribed Tetanic Symptoms produced by Atropia in Cold-Blooded Animals, 434.
——— Preliminary Notice on the Antagonism between the Actions of Physostigma (Calabar Bean) and Belladonna, 587.
Fraser (Dr T. R.) and Dr A. Crum Brown, on the Changes Produced by direct Chemical Additions on the Physiological Action of certain Poisons, 228, 461, 556.
——— on the Physiological Action of the Salts of the Ammonium Bases, derived from Atropia and Conia, 461.
——— and Professor A. Crum Brown, on the Physiological Action of the Salts of Ammonia, of Tri-methylamine, and of Tetramethyl-ammonium; of the Salts of Tropia, and of the Ammonium Bases derived from it; and of Tropic, Atropic and Isatropic Acids and their Salts, &c, 556.
———on the Physiological Action of the Salts of Methyl-Strychnium and of Ethyl-Strychnium, 556.

Gamgee (Dr Arthur), Note on the Action of Nitric Oxide, Nitrous Acid, and Nitrites, on Hæmoglobin, 109.
——— and Professor Maclagan, on the Alkaloids contained in the Wood of Bebeeru or Greenheart Tree (*Nectandra Rodiæi*, Schomb.), 548.
Geikie (Archibald) on the Tertiary Volcanic Rocks of the British Islands, 71.
——— Address on the Progress of the Geological Survey of Scotland, 487.
Geological Phenomena of the Basin of the Firth of Forth, 550.
——— Survey of Scotland, Progress of, 487.

Geometric Mean and Arithmetic Mean, 309.
Geometrical Problem, 168.
Geometrical Reasoning Mathematically tested, 477.
Goodsir (John), Obituary Notice of, 196.
Greville (Robert Kaye), Obituary Notice of, 25.

Hæmoglobin, Action of Nitric Oxide, Nitrous Acid, and Nitrites on, 109.
Handyside (Dr P. D.) on Traces in the Adult Heart of its Transitions in form during Fœtal Life, 499.
Hartley (Sir Charles), Notice of Works designed for the Improvement of the Danube, 313.
Harvey (Sir George) on the Colour of Aerial Blue, 430.
Hausmann (John F. L.), Obituary Notice of, 21.
Heart, Adult, Traces in it of Fœtal Life, 499.
Hegel and the Metaphysics of the Fluxional Calculus, 555.
Heights, Determination of, from Observations of Atmospheric Pressure, 465.
High Tide on the East Coast of Britain, Note on, 296.
Hodograph, Note on the, 221.
Holophote, Double and Triple, &c., 157.
Honorary Fellows, Alteration of Law as to Election of, 517.
Home-Drummond (Henry), Obituary Notice of, 191.
Hydrogenium, Motion of Palladium Plate during the formation of, 504.

Iceland Spar and Rock Salt, Effects of Pressure upon, 134.
Intensified Gravity in Centrifugal Governors, 477.
International Organisation, Application of Relative Equality to, 113.
Ivory (James), Obituary Notice of, 20.

Jenkin (Professor Fleeming), Address on Cable-Testing, 454.
——— on the Practical Application of Reciprocal Figures to the Calculation of Strains on Framework, 516.
Johnston (Keith, jun.) on the Annual Range of Temperature over the Globe, 561.

Keith Prize awarded, 204.
Keith Medal presented to Professor Smyth, 227.

Law, Alteration, in reference to Honorary Fellows, 517.
Library, Donations to the, 37, 61, 70, 86, 105, 112, 125, 139, 156, 169, 205, 379, 440, 592.
Light as a Sanitary Agent, 2.
Lindsay (Dr W. Lauder), Observations on New Lichenicolous Micro-Fungi, 534.
Liquid Films, Figures of Equilibrium of, 76, 311.
Lorimer (Professor) on the Application of Relative, or Proportional, Equality to International Organisation, 113.

Macdonald (Professor) on the Growth, Development, and Situation of the Human Fœtal Heart, 519.
Macduff (Alex.), Obituary Notice of, 33.
Macfarlane (Rev. James), Obituary Notice of, 18.
M'Intosh (Dr W. Carmichael) on the Structure of the British Nemerteans, and on new British Annelids, 379.
——— on the Affinities and Classification of the Nemerteans, 545.
Maclagan (Professor), and Dr Arthur Gamgee, on the Alkaloids contained in the Wood of Bebeeru or Greenheart Tree (*Nectandra Rodiœi*, Schomb.), 548.
Maclaren (Charles), Obituary Notice of, 27.
Magnetic Declination, 168.
Makdougall-Brisbane Prize awarded, 453.
Marriage, Influence of, on the Death-rate of Men and Women in Scotland, 49.
Martin (Rev. Hugh), Note on Professor Tait's "Quaternion Path" to Determinants of the Third Order, 121.
——— on Centres, Faisceaux, and Envelopes of Homology, 134.
Mathematical Researches, 165.
Mathematics applied to Chemistry, 89.
Maxwell (J. Clerk) on the best Arrangement for producing a Pure Spectrum on a Screen, 238.
Meconic Acid, a Derivative of, 129.
Metaphysics of the Fluxional Calculus, 555.

Methyl-Strychnium and Ethyl-Strychnium, Physiological Action of the Salts of, 556.
Micro-Fungi, New Lichenicolous, 534.
Mirage observed in the Firth of Forth, 472.
Mill's Theory of Geometrical Reasoning Mathematically tested, 477.
Milne-Home (David) on the Boulder Clay of Europe, 529.
——— on the Basin of the Firth of Forth, and some of its Geological Phenomena, 550.
Mineral Concretions found near Carlisle, 120.
Moncreiff (Captain A), System of working Artillery, 485.
Motions and Colour upon Films of Alcohol, Volatile Oils, and other Fluids, 108.
Murphy (Joseph John) on the Causes of Volcanic Action, 583.
Musculus Rectus Thoracis in Man, 268.
Musculus Sternalis, Remarks on, 65.
Museum of Science and Art, 501.

Nectandra Rodiœi, Alkaloids in Wood of, 548.
Neill Prize awarded, 453.
Nemerteans, Affinities and Classification of, 545.
——— British, Structure of, 379.
Nitro-Prussides, an Easy Method of preparing, 90.
Non-saturated Hydrocarbons, Mechanical Arrangement adapted to illustrate Structure in, 82.

Obelisk at Alexandria, suggestion on its transport to Britain, 284.
Obituary Notices, of Dr Burt and of Sir David Brewster, 282.
——— 1866-67-68-69, 15, 36, 185, 204, 429.
Opening Address by Sir D. Brewster, 1866-67, 2.
——— 1867-68, 173.
——— by Dr Christison, 1868-69, 392.
Oscillations of Heterogeneous Interpenetrating Systems of Particles, &c., 165.

Palladium Plate, its Motion during the Formation of Graham's Hydrogenium, 504.
Parturition, Function of, Lower Limit of the Power exerted in, 163.
Pendulum, Compensation, of two Pieces, 67.
Pendulum, Motion of, affected by the Rotation of the Earth and other Disturbing Causes, 458.
Petrie (William) on the History of the Sun's Distance Determinations, and on Scriptural and Scientific Probabilities, 307.
——— on the Present State of the Sun's Distance Question, 517.
Phenyl Alcohol, Oxidation of, 82.
Physiological Instruments, 63.
Physostigma venenosum, Physiological Action of, 51.
Pinguiculas, Embryos of, 531.
Pinguicula vulgaris, Development of Flower of, 531.
Playfair (Professor Lyon), Notice of an Easy Method of preparing Nitro-Prussides, 90.
——— Obituary Notices of Dr Burt and Sir David Brewster, 282.
——— Notice of Death of Principal James D. Forbes, 453.
Poisons, Change in the Physiological Action, by direct Chemical Addition, 228, 461.
Polyzomal Curves, 217.
Power, Free, An-Atomic, or Transmissible, 512, 539.
Pyramid of Egypt, 235.
——— Paper noticed, 316.
Pyramidal Structures in Egypt and elsewhere, 243.
Pyridine, Action of Sodium on, 379.

Quaternion Path to Determinants of the Third Order, 121.

Rankine (J. Macquorn) on the Thermal Energy of Molecular Vortices, 590.
Reproductive Process in some Algæ and Fungi, 294.
Reusch (Professor) on the Effect of Pressure upon Rock Salt and Iceland Spar, 134.
Rhabdopleura, a new genus of Polyzoa, 438.
Rhabdopleura Normani, Allman, 439.
Richardson (Thomas), Obituary Notice of, 198.
Robertson (George), Note on a recent High Tide in the East Coast of Britain, 296.
Rock Salt and Iceland Spar, Effect of Pressure upon, 134.
Rogers (Henry D.), Obituary Notice of, 22,

Rosse (Earl of), Obituary Notice of, 199.
Rotation of a Rigid Body round a Fixed Point, 420, 592.
Royal Society of Edinburgh, History of, 393.
Russell (Robert) on the Nature and Character of European Winter Storms, and the best Means of giving Warning of their Approach, 140.
——— on the Rectangular Current Theory of Storms, illustrated by two Storms which passed over the United States from 13th to 19th March 1869, 525.
Rutherford (Dr Wm.), Influence of the Vagus upon the Vascular System, 538.

Sandstone, Flexible, a variety of, 485.
Sang (Edward) on some Phenomena of Indistinct Vision, 58.
——— on Compensation Pendulums of two Pieces, 67.
——— Method of ascertaining the Specific Gravity of Water which holds a minute quantity of Foreign Matter in solution; or, on the Specific Gravity of Impure Water, 78.
——— on the Vibration of a Uniform Straight Spring, 150.
Scientific Education, 173, 185.
Scoresby-Jackson (Robert E.), Obituary Notice of, 197.
Scott (John) on the Burning Mirrors of Archimedes, and on the Concentration of Light produced by Reflection, 232.
Sense Perception, as a Perception of Power, 539.
Simpson (Sir J. Y.) on Pyramidal Structures in Egypt and elsewhere; and the Objects of their Erection, 243.
Smith (James), Obituary Notice of, 200.
Smith (W. R.) on Hegel and the Metaphysics of the Fluxional Calculus, 555.
——— Mr Mill's Theory of Geometrical Reasoning Mathematically tested, 477.
Smyth (Professor C. Piazzi) on the Antiquity of Intellectual Man, from a Practical Astronomical Point of View, 226.
Smyth (Professor C. Piazzi), Remarks on two Pyramid Papers in the Proceedings of the Royal Society of Edinburgh, 316.
——— Practical Note on Intensified Gravity in Centrifugal Governors, 477.
Soap-Bubble, Colours of the, 64.
Sodium, its Action on Pyridine, 379.
Sophists of the Fifth Century, B.C., 119.
South (Sir James), Obituary Notice of, 202.
Specific Gravity of Impure Water, 78.
Spectrum, on the Radiant, 147, 167.
——— on the best Arrangement for producing a Free Spectrum on a Screen, 238.
——— Vapour Lines in the, 145.
Spores of Cryptogamic Plants, 294.
Spring, Uniform Straight, Vibration of, 150.
Stark (James, M.D.) on the Influence of Marriage on the Death-Rates of Men and Women in Scotland, 49.
Stevenson (Alan), Obituary Notice of, 23.
Stevenson (David), Notice of Works designed by Sir Charles Hartley for the Improvement of the Danube, 313.
Stevenson (James), Obituary Notice of, 34.
Stewart (John), Obituary Notice of, 203.
Storms, European Winter; their Nature and Character, &c., 140.
Storms, Rectangular Currents, Theory of, illustrated, 525.
Strains on Framework, Practical Application of Reciprocal Figures to the Calculation of, 516.
Sun's Distance, Determinations, 307.
Sun's Distance, Present State of the Question, 517.
Symbolical Cubic which expresses the Properties of a Self-conjugate Linear and Vector Function, 92.

Tait (Professor), Note on Determinants of the Third Order, 59.
——— Note on the Reality of the Parts of the Symbolical Cubic which expresses the Properties of a Self-conjugate Linear and Vector Function, 92.

Tait (Professor), Note on a celebrated Geometrical Problem, 165.
——— Note on the Radiant Spectrum, 167.
——— Note on the Hodograph, 221.
——— Note on an Inequality, 292.
——— Exhibition of a very easy mode of demonstrating Balfour Stewart's results regarding Equality of Absorption and Radiation, 293.
——— on the Dissipation of Energy, 309.
——— Physical Proof that the Geometric Mean of any number of Quantities is less than the Arithmetic Mean, 309.
——— on the Rotation of a Rigid Body round a Fixed Point, 420, 30 592.
——— on the Motion of a Pendulum affected by the Rotation of the Earth and other Disturbing Causes, 456.
——— on Comets, 553.
——— Note on Electrolytic Polarisation, 579.
Talbot (H. Fox), some Mathematical Researches, 165.
Temperature, Annual Range of, over the Globe, 561.
——— of the Common Fowl, 288.
Tertiary Volcanic Rocks of the British Islands, 71.
Thermal Energy of Molecular Vortices, 590.
Thomson (J.), Illustrations of the Antiquities and Scenery of Cambodia, 112.
Thomson (R. W.), Note on Captain Moncrieff's System of working Artillery, 485
Thomson (Sir William), on Vortex Atoms, 94, 167.
Tresca (M.) on the Flow of Solids, with the Practical Applications in Forgings, &c., 311.
Tristram (Rev. H. B.), Address on the Recent Scientific Researches in Palestine, 271.
Tropia, Physiological Action of Salts of, 556.
Tropia and Atropic Acids, Physiological Action of, 556.
Turner (Professor) on the Musculus Sternalis, 65.
——— Note on the Occasional Occurrence of the Musculus Rectus Thoracis in Man, 268.
——— Notice of a Heart in which the Superior Vena Cava possessed a Valve at its Auricular Orifice, 455.

Vagus, influence of, upon the Vascular System, 538.
Varying Weights, by Minute Quantities, 167.
Vena Cava, Superior, Valve at its Auricular Orifice, 455.
Vision, Indistinct, some Phenomena of, 58.
Volcanic Action, causes of, 583.
Vortex Atoms, 94, 167.

Wackerbarth (A. D.) on the Great Pyramid of Gizeh, and Professor C. P. Smyth's Views concerning it, 235, 317.
Whewell (William), Obituary Notice of, 29.
Winds, Prevailing, for the Months and for the Year, 523.
Wyld (Robert S.) on Free, Anatomic, or Transmissible Power, 512, 539.
——— on Animal Power, and on Sense Perception as a Perception of Power, 539.

ERRATA.

Page 36, line 17 from bottom, *for* Dr John Alexander Smith, *read*, Dr John Smith. Dr J. A. Smith was elected in 1863.

Page 200, line 3 from the bottom, *for* twelve, *read*, six.

Page 201, line 3 from the top, *for* after the peace in 1814, *read*, in the years 1818, 1819.

Page 202, line 8 from the top, *for* he left, *read*, had.

Page 202, lines 10, 11, and 12, *from* " the wife," to the end of the paragraph, *read*, and two daughters—Mrs Isabella Gore Booth, married to a son of the late Sir Robert Gore Booth of Lissadel, Sligo; and Sabina, unmarried. Christian, wife of Walter Buchanan, Esq., M.P., died 30th April 1852; and Louisa, wife of the late William Hamilton, Esq. of Minard, died 2d March 1863.

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PAGE

Monday, 5th April 1869.

On the Present State of the Sun's Distance Question—*continued.* By W. Petrie, Esq. Communicated by Professor C. Piazzi Smyth, ... 517
On Chemical Structure. By Dr A. Crum Brown, . . 518
Observations on the Temperature of Newly-born Children. By T. J. Maclagan, M.D., Dundee. Communicated by J. Matthews Duncan, M.D., ... 519
On the Growth, Development, and Situation of the Human Fœtal Heart. By Professor Macdonald, . . 519

Monday, 19th April 1869.

The Mean Pressure of the Atmosphere, and the Prevailing Winds for the Months and for the Year. Part II. By Alexander Buchan, Secretary of the Meteorological Society, ... 523
On the Rectangular Current Theory of Storms, illustrated by two Storms which passed over the United States, from the 13th to 19th March 1869. By Robert Russell, Esq., ... 525
On the Boulder-Clay of Europe. By D. Milne-Home, Esq., 529
On the Development of the Flower of *Pinguicula vulgaris*, L., with Remarks on the Embryos of *P. vulgaris*, *P. grandiflora*, *P. lusitanica*, *P. caudata*, and *Utricularia minor*. By Alexander Dickson, M.D. Edin. & Dublin, Regius Professor of Botany in the University of Glasgow, 531
Observations on New Lichenicolous Micro-Fungi. By Dr W. Lauder Lindsay, ... 534
On the Theory of the Formation of Ammonia when Nitrogen and Aqueous Vapour are passed over Magnesium. By A. R. Catton, M.A., ... 536

Monday, 3d May 1869.

Iufluence of the Vagus upon the Vascular System. By William Rutherford, M.D., F.R.S.E., Demonstrator of Practical Physiology in the University of Edinburgh, ... 538
On Free An-atomic or Transmissible Power. By R. S. Wyld, Esq. (*Second Paper*), ... 539
On the Affinities and Classification of the Nemerteans. By W. C. M'Intosh, M.D., &c., ... 545

[*Turn over.*

PAGE

On the Alkaloids contained in the Wood of the Bebeeru or Greenheart Tree (*Nectandra Rodiœi*, Schomb.) By **Douglas Maclagan**, M.D., F.R.S.E., Professor of Medical Jurisprudence in the University of Edinburgh, and **Arthur Gamgee**, M.D., F.R.S.E., . . 548

Monday, 17*th May* 1869.

On the Basin of the Firth of Forth, and some of its Geological Phenomena. By **David Milne-Home**, Esq., . 550

On Comets. By Professor **Tait**, ... 553

Hegel and the Metaphysics of the Fluxional Calculus. By **W. R. Smith**, Esq. Communicated by Professor **Tait**, 555

On the Connection between Chemical Constitution and Physiological Action:—On the Physiological Action of the Salts of Ammonia, of Tri-methylamine, and of Tetra-methyl-ammonium; of the Salts of Tropia, and of the Ammonium Bases derived from it; and of Tropic, Atropic, and Isatropic Acids and their Salts. With further details on the Physiological Action of the Salts of Methyl-Strychnium and of Ethyl-Strychnium. By Professor **A. Crum Brown** and Dr **Thomas R. Fraser**, 556

Monday, 31*st May* 1869.

On the Annual Range of Temperature over the Globe. By Mr **Keith Johnston**, jun. Communicated by Mr **Buchan**, Secretary of the Scottish Meteorological Society (*with a Plate*), ... 561

Note on Electrolytic Polarisation. By Professor **Tait**, . 579

On the Causes of Volcanic Action. By **Joseph John Murphy**, Esq. Communicated by Dr Wyville Thomson, 583

Preliminary Note on the Antagonism between the Actions of Physostigma (Calabar Bean) and Belladonna. By Dr **Thomas R. Fraser**, ... 587

On the Thermal Energy of Molecular Vortices. By **W. J. Macquorn Rankine**, C.E., LL.D., F.R.SS. Lond. and Edin., &c., ... 590

On the Rotation of a Rigid Body round a Fixed Point. Part II. By Professor Tait, ... 592

Donations to the Library, ... 592